

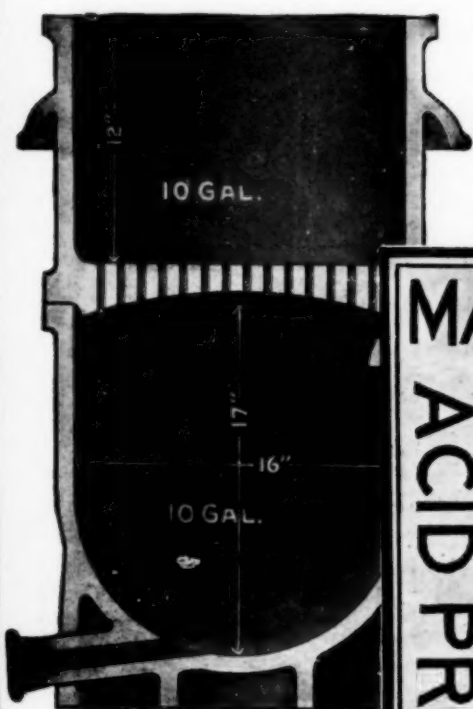
CHEMICAL & METALLURGICAL ENGINEERING

New York, September 1, 1919

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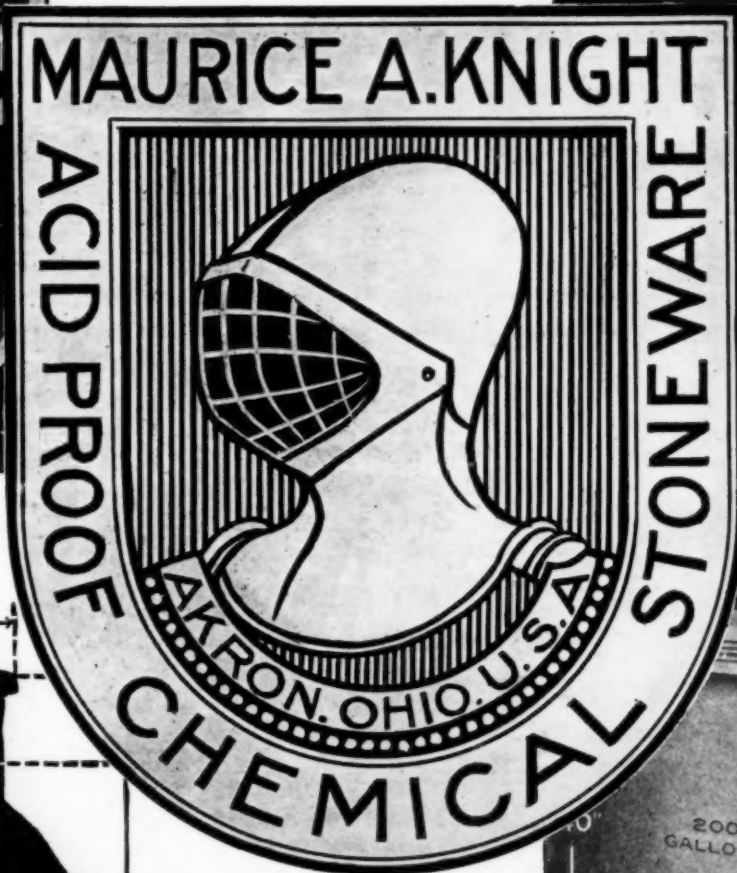
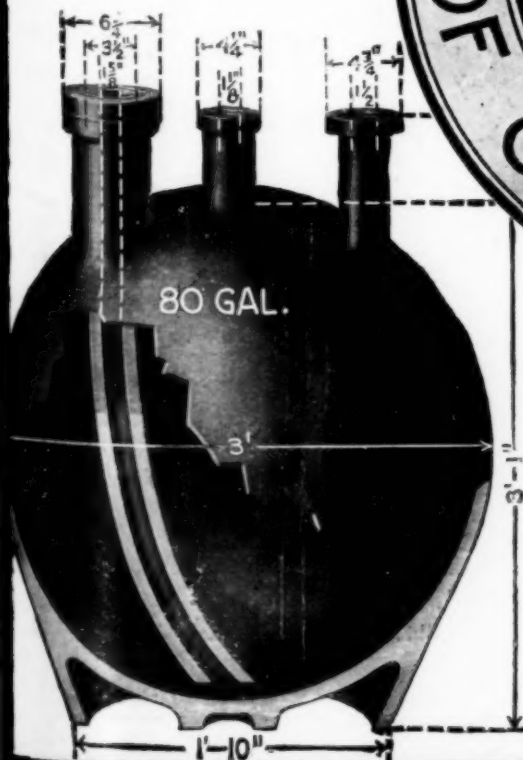
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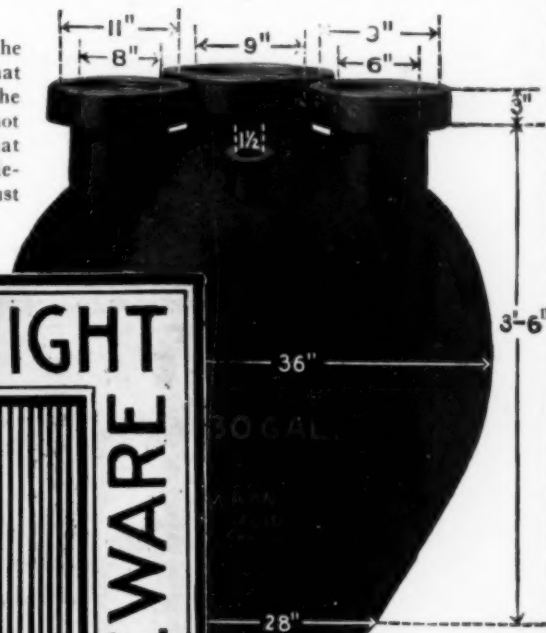


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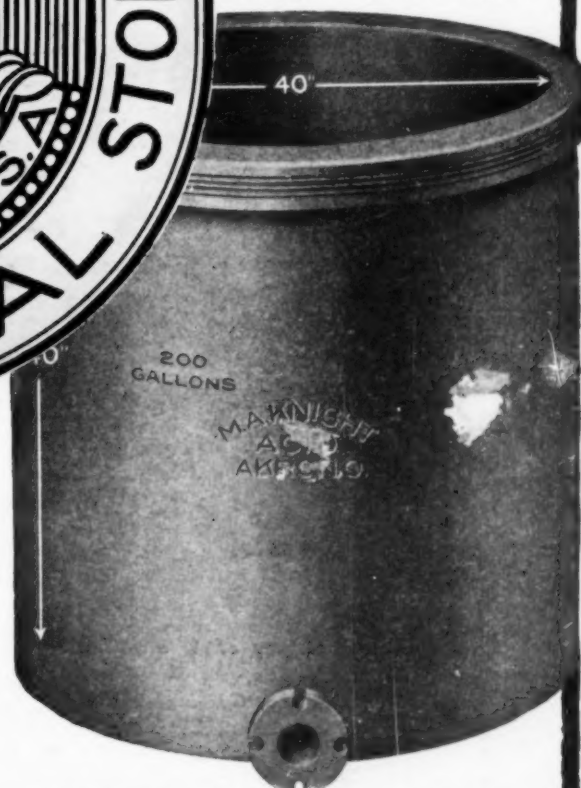
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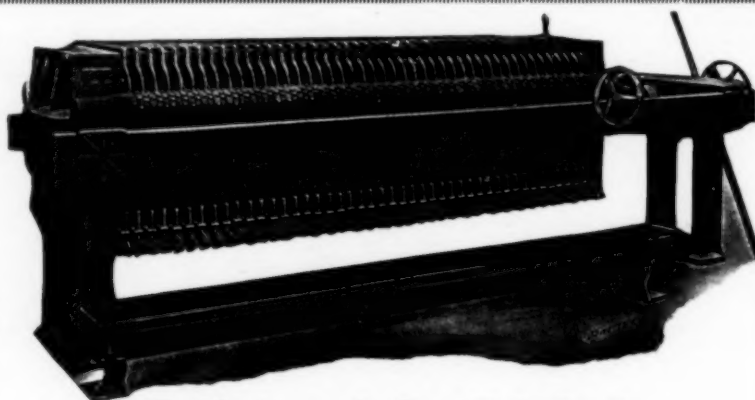
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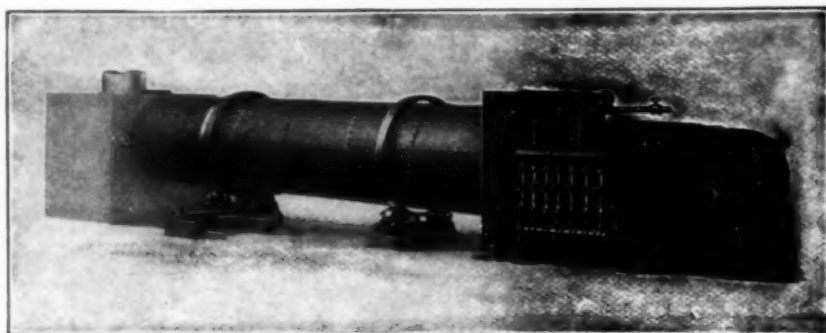
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Number 5

Fifth National Exposition Of Chemical Industries

IN THE last week in September chemistry moves to Chicago, along with the National Exposition of Chemical Industries. This will be the fifth of the kind and it bids fair to outstep all previous efforts.

The value of these expositions has been proved many times, and many things have been learned both by the management and by exhibitors. For instance, it is not profitable to draw a crowd just to show something unusual. The rubberneck is not a purchasing organism. On the other hand, whenever a betterment or economy is made clear and evident to the understanding mind, it brings immediate response and inquiry. In other words, the Exhibition is one of applied technology, and not a demonstration in popular science. As an inducement to fond mothers to bring along their little Reginalds and Harolds, with a view to persuading them to study science and become great chemists, the show does not even attempt to function. To the chemical engineer it grows more interesting every year. To the—we may almost say millions of collectors of advertising catalogues who seem to visit every exposition to improve their minds by walking over miles of floor space, we are glad to say it bids less and less encouragement as the years roll on.

Jointly with the first Exposition was held the annual meeting of the American Electrochemical Society, and it was a great success. The following year the American Chemical Society as well as its Electrochemical cousin had an annual meeting during the Exposition. This proved too much of a good thing, for it was beyond physical endurance to be present at the many sessions that almost commanded attendance. The following year there were no meetings except the important symposia which constitute a daily feature. This year, with the exception of the American Chemical Society, the time is to be embellished with annual meetings of five important organizations: The American Electrochemical Society, the Technical Association of Pulp and Paper Manufacturers, the American Steel Treathers' Society, the American Mining and Metallurgical Engineers and the American Ceramic Society, which will all meet in conjunction with the show. And there are to be symposia and discussions and, as likely as not, manifestoes and declarations.

The program which we give in a special insert for the convenience of our readers is very elaborate and replete with interest. It should not be forgotten that the Exposition is going on at full tilt during all these frequent intellectual and occasional gustatory festivities. The list includes the various general and sectional meetings of the societies named with the exception of

those of the American Ceramic Society, which are not fully determined upon the time of our going to press. In addition to these and the meetings arranged for by the management of the Exposition, there will occur on Friday, the 26th inst., an event of historic interest; consisting in the award of the Willard Gibbs medal by the Chicago Section of the American Chemical Society to Professor W. A. NOYES.

The whole occasion is planned on a large scale, and we are heartened by the fact that, as our people begin to see the incidence of chemistry upon industry on every hand, they are getting the opportunity to learn how it touches them.

The management spends some 51 diligent weeks every year in getting the Exposition together and arranging the details. The result is a very concentrated show which technical chemists can ill afford to miss.

Shabby Treatment of Patent Examiners

THE Commissioner of Patents testified before the House Committee on Patents last month that resignations from his staff had increased from about 8 per cent in 1915-16 to over 25 per cent per annum in 1918-19. And under date of Aug. 26 the Civil Service Commission announces examinations to be held for "Patent Investigator (Male) \$1200 to \$1800 a year." For those having had the necessary preliminary instruction and three years' experience the opportunity is also offered to advance to "Expert Patent Investigators at \$1800 to \$2400 a year."

This reminds us of a picture lately printed, of a man applying for a position. The prospective employer declares that they require two years' post-graduate work and five years' professional practice and that the salary is \$1800 a year. The applicant says, "Say, Boss, I ain't never had no education," to which the employer replies, "Oh, excuse me! Welcome to our works. Your wages will be \$7 a day. Come with me."

The service affords excellent training for men who want to become patent solicitors and attorneys, but we are not short of patent attorneys. There are enough of them to take care of the business offered. On the other hand there is a serious shortage of good examiners. The salaries paid do not make the posts attractive except to those who intend to enter legal practice, and these may be expected to leave as soon as they feel themselves capable. From an economical standpoint a young man stands as good if not a better chance if he goes "braking" on a railroad. Of course he would miss the pleasant living conditions and de-

lightful society that Washington offers when the stress of war is raised, but this applies particularly to applicants of a gregarious nature. Many are not. And if the applicant regards the salary of \$100 a month as good pay—it being nearly the price of unskilled labor with steady work—it may be that he lacks the natural gifts to be a good patent investigator.

Once upon a time there were two children of poor but honest parents. "I will be a barber when I grow up," said the boy. "It is light, easy work and there are tips for nearly every job." "And I," said his sister, "will be a manicure and then I may marry a prominent club man or a millionaire." But they bethought themselves that public school teachers have three months vacation every summer, and so they became teachers. Thus were an excellent barber and a natural born manicure lost to society, while the educational system of their native city was not at all improved by their presence as instructors.

This fable teaches us that in the Patent Office the requirements for mental equipment are different from those of a barber shop. Comment on desirable compensation is superfluous.

Does American Potash Need a Fixed Price?

AMERICAN potash appears at once to be the child and victim of propaganda. First we had no industry because the Germans assured us that their proven resources of crude salt which could be cheaply mined and shipped in quantity gave them domination over the world. Then when the blockade prevented importation of this desirable substance, the price soared to dizzy heights, and Americans were spurred by an insistent cry, "Give us potash!" to get into the game patriotically and make some money. Apparently there was money to be had, for newspapers far and wide, including those no less respectable and reliable than the *Chicago Tribune*, published "stories" a column long about the fabulous fortunes suddenly acquired by Nebraska potash magnates. No one seemed to take the trouble to deny these wild tales, perhaps because they attracted needed capital to the infant industry and increased our potential supply of salts, or because one recognizes that reasoning beings do not believe such lurid stories should they by chance be read. Here was a grievous sin of omission, however, for the selfsame "potash magnates" are now hard put to explain why they still need the fostering care of governmental price fixing and the limitation of imports to allow them to live and, as they put it, to "reorganize on a peace basis."

There is no question that the production of American potash in quantity is essential for our national well-being. No American wants us again to be dependent solely upon the Germans for any substance required in our domestic economy. If he knows the true story, he will not begrudge the fancy price he had to pay for war-time production. But isn't it about time, after five years of absolute embargo and high returns, that the infant industry show signs of being able to stand on its own feet? If it cannot approach that point under such conditions will it ever be able to walk alone? Will costs in this and other instances have to be indefinitely upheld by the power of a government whose people are demanding relief from high prices with a voice never before so unanimous or insistent?

The truth of the matter is this: That the American potash industry can stand on its own feet, and can now compete with foreign importations, barring dumping, trade war, rebates and such unfair practices; and the sooner the American potash industry comes before the people of the United States with clean hands the better it will be for its good name. Of course there is more money to be had, and that easily, by getting a price fixed for its production, at say \$2.50 per unit, than there is in devising ways and means to cut its own costs so they are proof against competition. It's good business, too, the kind of good business that has placed the world over a trembling volcano of industrial unrest. But the other is the good technology which CHEMICAL & METALLURGICAL ENGINEERING will always insist upon: The production of more material for a smaller expenditure of labor and money, an increase in the efficiency of effort and dollars, and the only apparent escape from the present *cul-de-sac* of high wages but higher prices.

Mr. W. E. RICHARDSON, of the Nebraska Potash Producers' Association, and Mr. A. C. HARRAGIN, secretary of the American Trona Corporation, have presented detailed costs of producing potash in 1918 before the House Committee on Ways and Means in support of the so-called licensing bill, which may be restated as follows:

	Nebraska		Trona	
	Per Ton of Crude Salt 20% K ₂ O	Per Unit K ₂ O (20 Lb.)	Per Ton of Chloride 50% K ₂ O	Per Unit K ₂ O (20 Lb.)
Fuel, labor, repairs, selling and overhead.....	\$37.80	\$1.89	\$32.97	\$0.66
Freight on salt to market....	13.00	.65	17.72	.35
Capital charges.....	16.40	.82	61.71	1.24
Royalty.....	17.60	.88	.....	.....
Total.....	\$84.80	\$4.24	\$112.40	\$2.25

The less said about the unholy figure for royalty the better. Capital charges appear to be high, especially for the Trona company, where, strangely enough, it is nearly twice as much as the entire operating expense. The bulk of these charges appears to be amortization of investment, designed to be entirely liquidated in two years—evidently unreasonable for going concerns, such as we hope to prove the potash industry to be. Freight is something outside the power of the producer, unless he ships a more concentrated salt. That brings us back to the net operating—\$1.89 a unit (9½c. a lb.) in Nebraska and \$0.66 a unit (3.3c. a lb.) at Searles Lake.

Nebraska operators evaporate brackish lake water to dryness, and it costs them 9½c. to put each pound of potash in the resulting crude on cars at no profit! The water is there for the pumping. No purification of any sort is necessary. Merely evaporate 60 lb. of water and sack the dirty crystals. Just how careful of outgo the Nebraska men must have been may be judged by a comparison with the beet sugar industry. These men can pay 4c. per lb. to the farmers for the sugar in the beets, collect them by rail, wash, shred and leach the cosettes, evaporate the solution, crystallize and purify the sugar, add in all capital charges and sell refined sugar at wholesale at 9c. a lb. and still get rich at it! Or compare the cost of the Trona company—3.3c. per lb. At Searles Lake the brine is not only evaporated, originally more concentrated, it is true, but in addition a quite delicate separation of large percentage of deleterious salts is necessary before the crystals can be sold.

Using multiple-effect crystallizing evaporators and filters, with reasonably good boiler practice, Nebraska

potash can unquestionably be produced f.o.b. factory now at \$0.66 per unit, the same as the Trona product, including all charges except capital charges—interest and depreciation. Accepting Mr. SHARP'S statement that four plants with actual output in 1918 of 12,750 tons pure potash cost \$2,500,000, capital charges of 34c. per unit would equal 17 per cent for interest and depreciation. Mr. HARRAGIN, by the way, asks for only an ultimate 23c. Consequently with correct technology, the average plant operating on brines—and this source yielded three-quarters of our last year's supply—will not go into bankruptcy if it can get \$1 a unit for its potash, f.o.b. plant. Even though the pre-war cost of German potash, f.o.b. American ports, was \$0.75 a unit, it is not likely that this price can be approached for some time—in fact future delivery of Alsatian salts has been quoted at \$1.70 per unit, even though spot American potash is being sold at \$2.25.

Everything considered, it appears certain that the American industry need not fear strangulation from fair foreign competition. In fact, we believe that eventually potash from cement kilns, iron furnaces and sugar mills will command the market and give the brine plants cause for most worry. Who will protect them against this competition, if they do not immediately clean house and reduce their costs, which they admit they can do? In our opinion the potash industry would have the best chance of success if it went before the Tariff Commission, Congress and the President and said: "We can put potash aboard cars as cheaply as the European can put it aboard ships. All we ask is that their advantage in ocean freight rate over our long rail-haul be equalized by a proper protective tariff." This would square them with the only rational tariff policy acceptable to both political parties, disarm suspicion of ulterior motives, eliminate obnoxious licensing and price fixing, and unite all candid members of the industry solidly behind the movement.

A Truce in Labor Demands

THERE is no doubt that President WILSON'S statement made public August 26 will mark the turning point in labor demands. The occasion of the President's utterance was his giving advice that the demands upon the Railroad Administration by the railroad shopmen should not be granted, but he was clear and emphatic in indicating that his observations were of general application. He spoke of "the demands of the shopmen and all other demands." He said, "It is the duty of every citizen of the country to insist upon such a truce" and he appealed to his "fellow citizens of every employment to co-operate in insisting upon the maintaining of such a truce."

The basic idea is that which has been in the minds of most employers and thinking men, that these continued wage advances get us nowhere. The increase in production cost is added, with an increment, to the producer's selling price, and more is tacked on along the line. Then the wage earner experiences more "high cost of living" and makes a fresh demand. The thing to do is to reduce the cost of living and "any substantial increase of wages in leading lines of industry at this time would utterly crush the general campaign the Government is waging, with energy, vigor and substantial hope of success, to reduce the high cost of living."

There can be no doubt that when the President mentioned "leading lines of industry" he had in mind the

case of the iron and steel industry. Six days before the President issued his statement the American Federation of Labor's "National Committee for Organizing Iron and Steel Workers" had announced the result of its "strike vote," taken during the 30 days preceding, as 98 per cent affirmative and had appointed a committee of six to seek a conference with the iron and steel producers, the committee having until August 30 to arrange for a conference, failing in which it was authorized to call a strike.

The American Federation of Labor demands were embodied in a platform of twelve planks, given to the press July 20 after the meeting of representatives of 24 unions who decided to take a "strike vote." The strategy was good. The unions represented included those of machinists, bricklayers, molders, plumbers and steam fitters, switchmen, stationary firemen, electrical workers and similar crafts. Many of these unions have strong memberships employed outside the iron and steel industry and the withdrawal of a few of the crafts would greatly cripple mill and furnace operations, even though the strikers comprised but a very small percentage of the total number of men employed. The strategy lay in attempting to produce a strike with a small number of men, the strike being to force complete unionization of the industry. The organizing committee would furnish simply the skeleton and the employers themselves would be required to fill out and make the organization complete.

This was aimed at by nothing less than the odious "check-off" which was No. 9 of the twelve demands, No. 1 being "collective bargaining." These two points, however, would merely establish the union. To make a union function as union men want unions to function the man must be made a non-entity, with no personality, no particular degree of skill, nothing to distinguish him from other men. To destroy individuality, to kill efficiency and to complete the surrender of the plants to the men, the following requirements were incorporated in the demands: No. 7, "Standard scales of wages for all crafts and classifications of workers," and No. 10, "Principle of seniority to apply in maintaining, reducing and increasing working forces." Lest it be thought that these two demands would represent so utter a surrender that nothing further could be asked, it must be mentioned that there were two more along this line, No. 2 calling for "Reinstatement of all men discharged for union activities with pay for time lost," when of course the claim would be made that all union men discharged had been discharged on that account, and No. 12, "Abolition of physical examination of applicants for employment." That is a confession that the organizers consider it profitable under the liability laws for a workman to be injured, even though it was not the injured who was physically unfit, but his fellow workman.

It is significant that in the platform as a whole demands representing directly or indirectly wage advances or decreases in the hours of labor were distinctly subsidiary, though of course such demands would be insisted upon. Granting the demands would involve not only the increase in production cost directly arising from higher wage rates and shorter hours but also a great increase due to lessened efficiency, and it is well indeed that the American Federation of Labor program has been dealt a stunning blow by the pronouncement of the President that there must be a truce in these things.

Western Chemical and Metallurgical Field

Colorado Potash Company

THE following brief description of the Colorado Potash Co.'s activities has been given to us by Dr. J. Gillingham Hibbs of Denver, Colo. The company was organized and operated by Fuller-MacCulloch Co., a partnership consisting of Messrs. Edmund Fuller and Thomas MacCulloch, both of Denver, who have been developing a process for the production of potash by the electrolytic decomposition of feldspar and leucite under a patent recently issued.¹

Feldspar is found within 20 miles of Denver in ample quantity for any production hoped for in that region, and is mined by benching in the open. This matter of proximity of supply yields a low cost of raw stock. The rock is crushed to about 60 mesh, decomposed in digesting pans and electrolyzed in special earthenware cells to potassium aluminate, with an accompanying complete segregation of the silicon content of the rock.

The crux of the process is the diaphragm cell. This special porous pot contains the cathode, immersed originally in pure water contained within the diaphragm. Surrounding this and inclosed in the cell body itself is the sulphuric acid solution of decomposed feldspar, in which the anode is immersed. Impressed current now ionizes the solution, and the alkali and aluminum travel through the diaphragm, forming KAlO_2 at the cathode, while amorphous silicon remains as a sludge about the anode. By insertion of proper tanks and pumps the electrolysis can be made continuous, fresh solution replacing the silica-bearing sludge, and water the alkaline aluminate.

The KAlO_2 is broken down by action of CO_2 , resulting in aluminum hydrate and K_2CO_3 ; the latter remaining in solution while the $\text{Al}(\text{OH})_3$ is precipitated. The K_2CO_3 solution is decanted, the remaining aluminum hydrate washed and dried by an atomizing process. The potash solution is now in a condition for the production of any desired commercial salt. This liquor contains practically 100 per cent potassium or sodium carbonates, the potash content being in the same ratio as in the original feldspar. With the material used the potassium salts will be greater than 90 or the sodium salt less than 10 per cent. There is no magnesium in it, wherein it differs from the Nebraska and Salt Lake brines. It is also free from chlorides, which is a feature of leading importance in tobacco fertilization.

At present the firm is addressing itself to the production of 100 per cent soluble K_2SO_4 , which is accomplished by digestion with gypsum, whereby a pure calcium carbonate is precipitated. The solution is decanted, or after washing the precipitate the solution is also dried by an atomizing process.

Work is now under way to perfect various mechanical features of the process, particularly washing and handling the flocculent alumina precipitate. This, being free from iron and other deleterious impurities, should be available for the production of metallic aluminum. Large quantities of amorphous silica, containing some aluminum compounds, are also separated from the circulating electrolyte, and this mate-

rial will probably be welcomed by the ceramic industry. When the problems in chemical engineering connected with the production of potash salts have been solved in the present small-scale unit, the company intends to install duplicate cells and equipment in its roomy plant sufficient to produce 300 tons K_2SO_4 per month, with its accompanying 165 tons Al_2O_3 and 700 tons silica. Eventually, the company plans erecting numerous plants near agricultural centers, where sufficient supplies of potash-feldspars, gypsum and phosphate may be obtained, and market a 100 per cent soluble material comprising a balanced proportion of potash, phosphate and nitrate.

Preliminary experimentation has convinced Dr. Hibbs and his associates that they can eventually supply the Middle West with its fertilizer requirements in potash and potash in combination with nitrogen and phosphorus at less than pre-war costs, provided, always, the farmer can be educated to the use of concentrated plant foods. A model garden of 14 acres is in preparation to demonstrate the advantages in the use of pure salts over fertilizers having a large filler content.

The Vanadium Situation

The demand for alloy steels containing vanadium is large and there will undoubtedly be an increasing demand for these alloys. The automotive industry is active, particularly in the production of trucks and tractors, and this industry is the largest consumer of these steels at present. However, the stock on hand seems to be sufficient for requirements and the market is quiet. Ferrovanadium, 30 to 40 per cent, is quoted at \$5.50 to \$7 per pound of contained vanadium.

About three-fifths of the vanadium consumed in this country is obtained from Peru. The remainder is produced from deposits in the Western States and of this about nine-tenths is mined at Vanadium, Colo. Scattered mines, principally in Arizona and New Mexico, supply the remainder, excepting a small amount which is produced as a by-product from radium ores. The American Vanadium Co. produces ferrovanadium from the South American ores and the Primos Chemical Co. from domestic ores, these two companies being the largest in the field. The mill of the Primos Chemical Co., which was destroyed by fire, has been rebuilt and started operating at full capacity Aug. 1.

The trend of ferrovanadium prices will probably be determined by the cost of production from the domestic ores. It is also probable that this trend will be upward due to high wages, increasing depth of mining operations and a decreasing quality of ores obtained. This upward tendency should be checked by the production from as yet undeveloped sources and by the substitution of other alloy steels, particularly molybdenum.

Cuprodesclowitzite and vanadinite are possible sources of supply. Metallurgical methods for the treatment of these ores have been published.* A zincdesclowitzite has been discovered in Nevada; the quantity of this mineral available has not been determined as yet nor has a method been worked out for its metallurgical treatment. A large deposit, for a vanadium ore, occurs in the Shattuck-Arizona mine at Bisbee.

*"Treatment of Cuprodesclowitzite for the Extraction and Recovery of Vanadium, Lead and Copper"; J. E. Conley, *CHEM. & MET. ENG.*, vol. 20, p. 465.
 "A Proposed Metallurgical Process for the Treatment of Vanadinite for the Recovery of Lead and Vanadium"; J. E. Conley *CHEM. & MET. ENG.*, vol. 20, p. 514.

¹Potash Extraction, 1,253,560, Jan. 15, 1919.

Utah Copper Tailings Pond

With the growth of mining acreage and the scale of milling operations, the Utah Copper Co. encountered the problem of properly disposing of the tremendous amounts of tailings produced daily at its two mills. Thus, the early estimates of ore reserves at the mine in Bingham Canyon were 37,500,000 tons and, in 1907, the mill was expected to handle perhaps 5000 tons of ore daily. By purchase of the Boston Consolidated and other properties in the canyon, the existing ore reserves have now been increased ten

ponds with dikes paralleling the two transcontinental railroads on the north and south, with a maximum height of 92 ft., at an estimated cost of \$3,885,000. Such a mass of loose material in close proximity to the railroads would be a continual menace to their operation, and these schemes were abandoned.

It then appeared necessary to move the railroads. If they were shifted about a half-mile north and connected with the old lines at the old Garfield station, a dike about 30 ft. high would be needed to impound all tailings resting at a grade of 0.9 per cent. The cost of this scheme was about \$2,265,000. However, by moving the tracks still farther north, and rebuilding the Garfield station, a tailings area of 6000 acres could be provided, sufficient for all material, at an average slope of about 0.92 per cent without its toe encroaching on the railroads; in other words, without the necessity of diking, except, perhaps, to impound and clarify water before drainage into the lake. This plan, which was adopted, cost about \$910,000, chiefly for new lands and railroad revision. The latter item was by agreement done without cost to the railroads, a new roadbed being provided equal to the old, \$2000 per mile allowed for extra surfacing work until the roadbed settled, and an amount capitalized at \$46,000 for additional expense of operation due to added distance and curvature.

The North Tailings Pond, which was originally from 6 to 12 in.

under water, was first drained by digging the ditches eventually needed for tailings water, and the embankments made by drag-line excavator at a cost of 25c. per yard.

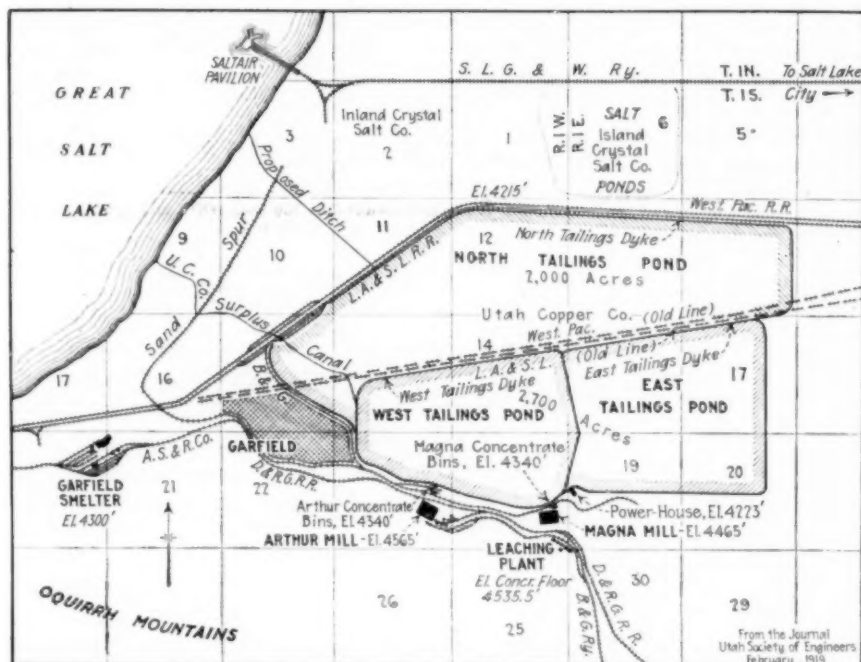
The 12-ft. dike is 7 miles long, furnished to a top width of 10 ft. for a railway track to handle riprapping, which latter is smelter slag placed for about 80c. per cubic yard.

Statistics on Turpentine and Rosin

As an aid to the development of the naval stores industry, statistics regarding production and supply of turpentine and rosin are being collected by the United States Department of Agriculture through specialists in the Bureau of Chemistry.

Blanks on which to report have been sent to all producers and users in the United States whose names and addresses are available. This information will show the amount on hand April 1, 1919, the quantity made this season up to Aug. 1, the amount actually on hand at the stills Aug. 1, and the estimated production for the balance of the season. It is expected that the data will be published by Sept. 1.

Similar statistics regarding last season's production and available supply of rosin and turpentine proved to be of much interest to producers and consumers alike. Information regarding last season's output, or blanks for reporting this season's supply, may be obtained upon application to the United States Department of Agriculture, Washington, D. C.



times, to 374,000,000 tons, despite mining in the meantime more ore than twice the original estimate. Milling during 1918 proceeded at the rate 33,317 tons daily, and the rated capacity of concentrators and leaching plant is no less than 43,000 tons. As Mr. H. C. Goodridge, their chief engineer, pointed out at a recent meeting of the Utah Society of Engineers, a tenfold increase in available ore and a ninefold increase in milling capacity has rendered insufficient the originally ample tailings area.

A map shown herewith gives a general idea of the location of the mills and smelter near the Great Salt Lake shore. The southwestern portion of this mapped area is rough, the Bingham & Garfield and Denver & Rio Grande railways skirting the Oquirrh Mountains, which rise directly out of the flatlands surrounding Salt Lake. Thus the mills are constructed on a hillside about 125 ft. above the general ground level to the north. Across this marshy flat some mile and a half away were situated the main lines of two transcontinental railways, and the intervening area has been used for tailings since the commencement of operations.

Various schemes for enlargement were studied by the mining company's engineers. Should all the expected ore be impounded in the so-called West and East Tailings ponds, it would require dikes around the area to an average height of 80 ft. and an eventual slope on top of the pond of but 0.5 per cent. The total estimated cost of this scheme was \$1,680,000. Another plan was based on making two independent

War-Time Activities of Dye Plants in Germany

THE report of the British mission appointed to visit enemy chemical factories in the occupied zone was introduced at the dyestuffs hearings before the House Committee on Ways and Means, in order to emphasize the military value of a well-developed chemical industry. The following data have been taken from this report. In some cases difficulty was experienced in obtaining accurate details of manufacture, especially as regards substances which have a peace value, and the information must be accepted with some reserve on this account, although it was checked by cross-examination of the officials concerned and by a careful examination of the plant admittedly employed for war purposes.

Some years before the war a combination was formed by the Bayer, Badische and A. G. F. A. companies and somewhat later a second group was formed which included Meister, Lucius & Bruning, Casella & Kalle. During the war these two groups amalgamated, and the Griesheim Elektron, Weiler-ter-Meer, Leonhardt and other smaller companies entered the combination, which is known as the I. G. (Interessengemeinschaft). It was largely owing to the efforts of this combination that Germany was enabled to continue the war in spite of the blockade. The I. G. works produced the bulk of the synthetic ammonia and nitric acid needed for the production of fertilizers and explosives, all the poison gas (with the exception of some chlorine and phosgene), and a large proportion of the high explosives.

The following are the more important works of the I. G. which were not visited, as they are outside the occupied zone:

Factories of the Aktien Gesellschaft für Anilinfabrikation.

Factories of the Griesheim Elektron Gesellschaft.

Factory of the Bayer Co. at Elberfeld.

Factory of the Badische Co. at Merseburg.

Factory of Casella & Co., Mainkur, near Frankfurt.

Factory of Leonhardt & Co., Mulheim, near Frankfurt.

A summary of the information obtained as to the war production of the factories visited is given under the headings of "Initial Products," "Explosives and Poison Gases."

INITIAL PRODUCTS FOR MANUFACTURE OF EXPLOSIVES AND POISON GAS.

The principal materials concerned are ammonia, nitric acid, sulphuric acid and chlorine, and it was on the output of these that the war production of chemical munitions depended. The expansion of output by the factories of the I. G. combination during the war is shown by Tables I-IV.

Explosives. No arrangements appear to have been made prior to the outbreak of war to utilize the resources of any of the dye factories for war purposes, and on mobilization their chemists were called up for military service. After the battle of the Marne the government realized the need for expanding the output of explosives and most of the chemical works were producing small quantities by the end of 1914. The demands made on them increased during 1915, but it was not until 1916 that plant was laid down to assist in the enormous production of explosives required by the Hindenburg program. Most of the big extensions of the synthetic ammonia and of the nitric and sulphuric acid plants date from this time, many chemists

being released from the army and the scientific staff of some of the works being augmented. Standardized plant used for the manufacture of dyes was converted for the production of explosives with remarkable speed;

TABLE I.—AMMONIA (METRIC TONS NH₃ PER DAY)

	1914	1918
Oppau.....	25	250
Merseburg.....	Nil	400
Total.....	25	650

TABLE II.—NITRIC ACID (METRIC TONS 100 PER CENT ACID PER DAY)

	1914	1918
Leverkusen.....	56	180
Hochst.....	150	375
Oppau*.....	?	100
Ludwigshafen.....	(?) 40	40
Weiler-ter-Meer.....	12	24
Total.....	258	719

* Oppau has the power to produce now 500 tons HNO₃ daily, still retaining sufficient ammonia to supply the output at Hochst.

TABLE III.—SULPHURIC ACID (METRIC TONS 100 PER CENT ACID PER DAY)

	1914	1918
Leverkusen.....	340	470
Hochst.....	224	280
Ludwigshafen.....	275	410
Weiler-ter-Meer.....	48	60
Total.....	887	1,220

Meister, Lucius & Bruning have also erected a large new plant at Hochst which has not yet started and was not examined.

The Bayer Co. has erected at Dormagen a large vitriol plant equal to 250 tons per day.

TABLE IV.—CHLORINE (METRIC TONS PER DAY)

	1914	1918
Leverkusen.....	7	20
Hochst.....	4	8
Ludwigshafen.....	13	35
Total.....	37	63

for instance, at Leverkusen a TNT plant producing 250 tons per month was put into operation in six weeks.

Tables V and VI show the amounts produced in the factories visited.

TABLE V.—HIGH EXPLOSIVES AND INTERMEDIATES

Quantities of intermediates are shown only where these were not converted to finished explosives in the producing works.

Factory	(Metric tons per week)									
	Ammonium Nitrate	Dinitrobenzene	Dinitrotoluene	Trinitrotoluene	Mononitro-naphthalene	Dinitronaphthalene	Dinitrochlorobenzene	Dinitrophenol	Picric Acid	Trinitroanisole
Leverkusen.....	250	...	250	...	150	40	...	...	600	3
Dormagen.....	...	...	...	...	...	...	...	...	...	...
Urdingen.....	60	...	75	(?)	...	...	...	...	...	...
Hochst.....	500	140	200	...	...	...	...	...	...	30
Ludwigshafen.....	25	50	...	...	15	300	35	...	...	25
Oppau.....	200	...	...	...	...	...	...	...	...	...
Merseburg.....	(?)	...	...	...	...	...	...	...	...	...
Wiesdorf.....	...	120	...	...	...	...	...	...	...	...
Schleibusch.....	100	...	150	...	...	...	...	...	...	...

¹ For 3 months only.

² Small.

³ For 1 year.

Other intermediates—Ludwigshafen, sodium benzene sulphonate, 100 tons per week.

Other explosives—Schleibusch, hexanitrodiphenylsulphide, 15 tons per week.

TABLE VI.—PROPELLANT EXPLOSIVES, DETONATING SUBSTANCES, ETC.

Factory	(Metric tons per week)						
	Nitro-cellulose Powder	Diethyl diphenylurea	Diphenylamine	Nitro-glycerine	Cordite Paste	Tetryl	Fulminate
Urdingen.....	...	35	7	...	...	...	...
Kupperateg.....	0.7
Troisdorf.....	250	...	...	21	40	6	0.7
Schleibusch.....
Opladen.....	35	75	...	...
Wiesdorf.....	(?) 50	40	...	...

Poison gas. At first chlorine and phosgene were the main requirements, but afterward a variety of organic substances were employed, all of which were made by

the factories of the I. G. combination. Many of these substances were new and difficult to prepare, and rapid production was only possible owing to the speed with which the peace organization of the dye factories could be utilized for this purpose. When the government wished to introduce a new gas, a conference of the various firms was held at Berlin to determine how the manufacture should be subdivided in order to use existing plants to the best advantage. For instance, the initial stages of the manufacture of mustard gas were carried out at Ludwigshafen and the final stage at Leverkusen.

Tables VII and VIII show the production of gas and intermediate products in the various factories visited.

TABLE VII—OUTPUT OF FINISHED POISON GASES FROM VARIOUS WORKS

Factory	Monthly Output (Metric Tons) Average	Maximum	Total Production (if known) Tons	Date of Commencement
1. Chlorine.....	Leverkusen..... 600	.....	.....	Prior to war
	Hochst..... 240	.....	.....	Prior to war
	Ludwigshafen... 860	1,261	38,600	Prior to war
2. Phosgene.....	Leverkusen..... 30	.....	.....	Prior to war
	Ludwigshafen... 288	621	10,682	Prior to war
3. Diphosgene....	Leverkusen..... 300	.....	.....	June, 1915
	Hochst..... 139	266	3,616	Sept., 1916
4. Chlorpicrin....	Leverkusen..... 200	.....	.....	July, 1916
	Hochst..... 45	101	1,127	Aug., 1916
5. Xylol bromide..	Leverkusen..... 60	.....	.....	Mar., 1915
6. Bromacetone....	Leverkusen..... 20	.....	.....	July, 1916
7. Bromacetone, bromomethyl-methylketone...	Hochst..... 19	45	685	Apr., 1915
8. Phenylcarbylamine chloride...	Hochst..... 65	124	721	Mar., 1917
9. Mustard gas....	Leverkusen..... 300	.....	4,500	Before July, 1917
10. Diphenylchlorarsine.....	Hochst..... 150	300	3,000	May, 1917
Diphenylcyanarsine.....	Hochst.....	.....	.....	Feb., 1918
11. Ethyldichlorarsine.....	Hochst..... 78	150	1,092	Aug., 1917
12. Dichloromethyl.....	Hochst..... 26	51	233	Sept., 1917
13. Dibromomethyl-ether.....	Hochst..... 7	29	69	Apr., 1917

¹ Estimated from capacity of plant. Probably the same quantity was produced at some other factory, as the output of thiodiglycol from Ludwigshafen would suffice for this.

TABLE VIII—OUTPUT OF INTERMEDIATE PRODUCTS FOR POISON GAS MANUFACTURE

Finished Gas	Intermediate Products	Total Output (Metric Tons)	Place of Production	Destination of Intermediate Products
Phenylcarbylamine..	Phenyl mustard oil..	(¹)	Kalle.....	Hochst
Mustard gas.....	Thiodiglycol.....	7,026	Ludwigshafen	Leverkusen and 1 other factory
Diphenylchlorarsine..	Phenylarsenic acid..	1,600	Ludwigshafen	Unknown
		1,200	Kalle.....	Unknown
	Diphenylarsenic acid	4,800	Leverkusen..	Probably A. G. F. A., Berlin
Ethyldichlorarsine...	Ethylarsenious oxide	840	Ludwigshafen	Hochst

¹ Not obtained.

Note.—In addition Hochst produced 3,000 tons of diphenyl chlor- and cyanarsines from own intermediates.

MILITARY IMPORTANCE OF THE GERMAN CHEMICAL INDUSTRY

These figures for the output of explosives and gas show the great military value of the factories of the I. G. combination. Although no arrangement had been made to mobilize them at the outbreak of hostilities, they were rapidly converted to war purposes, thanks to their highly trained personnel and the great technical resources of their peace organization. In the future it is clear that every chemical factory must be regarded as a potential arsenal, and other nations cannot therefore submit to the domination of certain sections of chemical industry which Germany exercised before the war. For military security it is essential that each country should have its chemical industry firmly estab-

lished, and this must be secured as one of the conditions of peace, as otherwise we are leaving Germany in possession of a weapon which will be a permanent menace to the peace of the world.

The key to Germany's war production of explosives was the Haber process for the production of ammonia from atmospheric nitrogen. It is significant that large-scale production by this process only began at the end of 1912, and that in the early part of 1914 great pressure was put on the Badische Co. to increase its output. During the war, owing to the extension of the Haber plants at Oppau and Merseburg, Germany has become independent of foreign countries for her supplies of ammonia and nitric acid, substances indispensable for the manufacture not only of high explosives but also of fertilizers for food production. Without such a process Germany could not have made the nitric acid required for her explosives program, nor obtained fertilizers for food production after the supply of Chile saltpeter had been stopped by the blockade, and it is probable that she could not have continued the war after 1916. In the event of another war we might be cut off from supplies of saltpeter.

The resources of the German dye industry are of no less military importance. Most of the gases employed toward the end of the war were complex organic substances, none of which had been made previously except in small quantities, and some of which were prepared for the first time during the war. Gas warfare will undoubtedly continue to develop in this direction, and in the future organic substances will be employed which we do not know today. The use of gas will always offer great opportunities for surprise in military operations, and the experiences of the present war have shown that rapid production of a new gas is essential if the surprise is to be effective. Any country without a well-developed organic chemical industry will be severely handicapped in this respect.

Re-employment Problems and Methods

ALTHOUGH the Victory Loan supplied the funds necessary to bring the boys from France, many of the returned soldiers, sailors and marines have experienced great difficulty in finding their places once more in the business world. This is especially true of young men who left college to enter the service and who now find it impossible to finish their courses, for financial or other reasons. In seeking employment, they find that the other men who have completed college courses have the preference and command the higher salaries, and yet in order to insure decent living conditions for themselves and their families, they feel that they must ask as much as the other men. They do not always get it, and for this reason an appeal is made to the employer of college-trained men to give men of this type a chance to make up in the plant or in the office the time lost while in service—to pay them a living wage during this period and to consider any resulting additional expense as an investment in the nature of a final Liberty Loan. These men made good Over There, and all that they ask now is the opportunity to show that they can do the same over here!

According to Mr. F. A. Giffin, in charge of the Placement Division for Executive, Professional and Technical Men of the Re-employment Bureau of New York City,

the problem of the inexperienced college man, as outlined above, is the greatest one with which the Technical Division has had to contend and yet one which may be easily solved, if employers will again show the spirit which made the Liberty Loans so successful.

The Re-employment Bureau of New York City was organized in April, 1919, to centralize all employment work for ex-service men in New York City. It has developed into a wonderfully efficient organization for bringing together the man and the job. The work is under the jurisdiction of the Re-employment Committee, of which William Fellowes Morgan, president of the Merchants Association, is chairman, and two advisory councils: the United Council of Re-employment, composed of representatives of seventeen welfare organizations and employment services, and the Employers' Council, composed of representatives of eighty-two commercial and trade organizations in Greater New York. The Bureau, which is under the immediate direction of Major Warren Bigelow, is divided into the following departments:

The Procurement Division has charge of obtaining sufficient jobs and of caring for unsolicited jobs which come in either by mail or by telephone.

The Registration Division has charge of registering the applicants and obtaining the information necessary for the Placement Division, and also classifying and routing the applicants to the proper placement sections, as well as filing cards and records of applicants and those who have obtained positions through the Bureau. The Registration Division has registered about 27,000 men.

The Vocational Division, which is a unique feature of the Bureau, endeavors to guide unskilled workers into trades which are not overcrowded and which will offer them a future.

The Placement Division consists of three main sections: General Placement, with eleven classified subdivisions such as, general labor, skilled mechanics, disabled men, salesmen, office clerks, etc.; Recruiting for Army, Navy, Marines, Air Service, Motor Transport Corps and the Shipping Board; Placement for Executive, Professional and Technical Men.

The last mentioned section takes care of all mental workers who receive \$1500 a year or over. About 12 per cent of the total registrants are referred to this division, i.e., about 200 per week. Of these, approximately 20 per cent are placed, 50 per cent find positions themselves or through some other agency or go back to their old jobs, while the remaining 30 per cent accumulate. (About 40 per cent of this class, which numbers over 700 at the present time, belong to the group of young college men referred to earlier in this article.) This division has placed over 500 men with an average salary of \$35 per week at a cost of \$9-\$10 per placement. The men registered range from privates to lieutenant-colonels and some have been placed in positions paying as high as \$25,000 a year. It is estimated that 95 per cent of the men placed stick to their new positions.

There is a great demand for skilled technical men, especially senior mechanical and electrical engineers, since the supply of graduate engineers has been shut off by the war. However, there is an oversupply of junior engineers and there is practically no demand for civil engineers, so that many of the latter are giving up their profession and entering a business career. Increased

activity in proposed construction work was first shown by the extraordinary demand for architectural draftsmen and later for structural draftsmen, concrete and steel designers.

Another problem is the placement of professional men, particularly lawyers and physicians, who have lost their practice while in service or who desire to change to some other line of work. Many physicians have expressed themselves as unwilling to return to the practice of medicine.

A summary of the work done by the Bureau as a whole from the date of organization until Aug. 25 shows that 27,000 men have been registered, 15,200 have been placed at an average cost of about \$5 per placement and that 66,000 positions have been registered by the Procurement Division.

Although the Army will be practically completely demobilized by the end of September, the Bureau has learned from experience that it takes from four to five weeks for the ex-service man to reach the Bureau after discharge and from two to three weeks more to place him, so that the work of the Bureau will in all probability continue until the first of November.

Philadelphia Meeting of the American Chemical Society

The fall meeting of the American Chemical Society will be held at the Bellevue-Stratford Hotel, Philadelphia, Pa., under the auspices of the Philadelphia Section, from Tuesday, Sept. 2, to Saturday, Sept. 6, inclusive. The Philadelphia Section, situated as it is so near the center of our chemical activities, is planning an extensive and unusual program.

The Rubber Division holds its first meeting and a Dye Section is to be established which will function as a separate section this year. The Industrial Division—organized in New Haven in 1908 for chemists in industrial research laboratories, for consulting chemists and chemical engineers and for business executives who find it profitable to keep in touch with the developments in applied chemistry—will hold a symposium on refractories organized by Dr. A. V. Bleining of the Bureau of Standards. A discussion will also be held upon Dr. B. C. Hesse's open letter concerning annual patent renewal fees for the United States.

The Chemical Warfare Service and the chemical fraternity Alphi Chi Sigma have planned reunions in conjunction with the meeting.

Among the many interesting papers to be read at the general and divisional meetings the following may be mentioned:

General Meeting—"Stream Pollution and Its Relation to the Chemical Industries," Earle B. Phelps; "The Building of Atoms and the Periodic Systems," W. D. Harkins.

Rubber Division—"The Action of Certain Organic Accelerators in the Vulcanization of Rubber," G. D. Kratz, A. H. Flower and Cole Coolidge; "Reactions of Accelerators During Vulcanization," C. W. Bedford and Winfield Scott; "The Effect of Organic Acceleration on the Vulcanization Coefficient," D. F. Cranor; "The Effect of Compounding Ingredients on the Physical Properties of Rubber," C. Olin North; "The Manufacture and Use of Crimson Antimony," J. M. Bierer; "Research on Zinc Products for the Rubber Industry," P. R. Croll and I. R. Ruby.

Division of Physical and Inorganic Chemistry—"A Slide Rule for Special Cases," F. C. Blake; "The Catalyst in the Oxidation of Ammonia," G. A. Perley; "A Metal to Glass Joint and Some of Its Applications," E. C. McKelvey and C. S. Taylor.

Division of Industrial Chemists and Chemical Engineers.—Report on the Production of Synthetic Organic Chemicals

The Export Trade Act

THE numerous requests for copies of the export trade act (Webb-Pomerene law) and the large number of inquiries about it call for the publication of a separate pamphlet¹ by the Federal Trade Commission for the information of those desiring to co-operate in the development of our foreign trade through association formed under that act.

We present herewith the outstanding features of this pamphlet.

A complete reprint of the Webb-Pomerene law (Public 126, 65th Congress) is given, together with such sections of the Sherman act, the Clayton act and the Federal Trade Commission act as are referred to in the Webb act. Five pages are devoted to a discussion of the act, including a summary of the law, a discussion of requests for rulings and a list of all organizations that have filed papers purporting to be under section 5 of the Export Trade act. One of the difficulties which exporting houses seem to find with the law is that export companies usually do both an export and import business, while the law provides that its protection is given to associations entered into for the sole purpose of engaging in export trade and actually engaged solely in such export trade.

PRACTICE AND PROCEDURE

In several instances suggestions have been made as to modification of proposed articles of incorporation, already filed, in order that these associations may clearly come within the provisions of the act. The commission is authorized by this law to make recommendations as to how export associations may conform their business to the law, and, within its powers, it proposes to advance step by step in aid of the export needs of the country. It desires to work constantly in co-operation with those who form export associations and also with those who may consider themselves or the public in any way injuriously affected by the methods and practices of such associations.

Where doubt exists as to whether a given method or practice is proper or not, it would seem advisable that the matter be voluntarily presented to the Commission in the early stages, without awaiting its later discovery and possible correction. The second paragraph of section 5 of the Webb act describes the few formalities as to such procedure.

The Commission has prepared blanks, available on request, for making the first and 1919 annual report which enables an easier compliance with section 5 of the Webb act.

Should it become necessary for an export association or for others engaged in the export trade to seek the enforcement of the Commission's power to prevent unfair methods of competition under section 4 of the Webb act the rules of practice do not require formalities in the filing of information or the lodging of complaints, but it is worth remembering that the fuller and more exact the information and references as to proof thereof the speedier the results before the Commission. This is especially true where the charges come from foreign countries where the time necessary for transmission might render the case academic through the sheer lapse of time. Where allegations come from abroad the pro-

cedure of the Commission can be more quickly set in motion if the papers are in such condition as to give the Commission "reason to believe" that alleged facts exist. Copies of letters, advertisements, exhibits and affidavits are extremely helpful, as also the names of witnesses and sources of information both in this country and abroad.

As the Commission can proceed on its own initiative, it is immaterial from what source its information is derived, but it is desirable, wherever possible, that for its confidential use the informant be known.

The Commission's investigation of foreign conditions, practices and combinations in foreign countries and its recommendations to Congress thereon will be greatly facilitated by American exporters keeping the Commission informed of their experiences and instances where their export business is restrained or injuriously affected by any matter or in any manner.

The Commission must depend largely for information and facts upon those who are interested in having the Commission correct any tendencies of export associations to artificially enhance or depress prices within the United States or otherwise burden the American public or restrain the commerce of independent competitors.

All mail for the export division should be addressed to the Federal Trade Commission, Washington, D. C., and marked "Export Division."

Government Soon to Make Armor and Heavy Forgings

The new naval ordnance plant at South Charleston, W. Va., is now about to begin the manufacture of armor plate and forgings for guns of large caliber, entirely new lines of work for Government plants. The South Charleston plant is a \$19,000,000 enterprise occupying more than 200 acres of land. It will be ready for making armor and heavy forgings as soon as the assembling of the necessary working force can be completed. Disturbed labor conditions incident to the war have been responsible for a delay in getting this work started. The new plant is equipped with every modern appliance for the manufacture of its specialties, and will turn out annually 50,000 tons of armor plate, guns, projectiles and miscellaneous ordnance forgings.

Engineers, metallurgists and mill and machine shop men will be interested in the positions which are to be filled in the supervisory and subordinate forces. The United States Civil Service Commission has announced for this plant the need of a superintendent of melting shops at \$5000 a year, a superintendent of forge shops at \$5000 a year, foreman of heat treatment of armor plate at from \$10 to \$14.40 a day, foreman of heat treatment of large guns at from \$8 to \$12.56 a day, foremen of 14,000-ton presses for armor and large-caliber guns at from \$11.84 to \$13.28 a day, foremen of small guns at \$8 a day and foremen of heat treatment of projectiles at \$8 a day. Applicants for these positions will not be given scholastic tests in an examination room, but will be rated on their training and experience, weighted at 90 per cent, and their physical ability, weighted at 10 per cent. Detailed information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C., or from the secretary of the local board of civil service examiners at the post office or custom house in any of 3000 cities. Journeyman workmen and helpers should apply direct to the labor board at the South Charleston plant.

¹"Discussion of and Practice of Procedure Under the Export Trade Act." Federal Trade Commission, Foreign Trade Series No. 1.

Metallography of Aluminum Ingot*

Study of the Microstructure of Aluminum Ingot—Influence of Quality of Ingot on the Resultant Castings—"Differential Group Etching," a Phenomenon Noticed in Etching Aluminum—Tentative Explanation of the Differential Etching

By ROBERT J. ANDERSON†

THUS far not much has been written on the metallography of aluminum, although there have been a few isolated papers on micrography of certain aluminum alloys. The microstructure of aluminum ingot has not been described, so far as the writer is aware. Hence information on this subject may be of interest to the light-alloy industry in particular and to metallographers in general. During the course of an investigation now being made by the Bureau of Mines in the metallurgy of aluminum, it became desirable to examine aluminum ingot in order to ascertain whether the quality of the original metal had any effect upon the quality of aluminum-alloy casting made from the metal. The final answer to that question is not yet in hand, but certain aspects of the metallography of ingot have been studied. Most foundrymen in the light-alloy industry are aware of variations in quality of aluminum ingot; therefore a microscopic method for determining quality should be of some value.

In the microstructure of aluminum ingot, a number of peculiarities still require explanation, and the present article deals briefly with some of these. In addition, this article discusses a phenomenon noticed in etching aluminum which, so far as is known, has not been described for other metals and alloys. This phenomenon, termed "differential group etching" by the writer, is so interesting that it seems to be worthy of description. There seems to be a fixed idea that the internal structure of aluminum is extremely simple; as a matter of fact, nothing could be farther from the truth.

PREPARATION OF MICROSECTIONS

The preparation of microsections of substantially pure aluminum is difficult at best; the numerous light alloys are, however, somewhat more easily prepared. Distortion of the surface is to be carefully guarded against, and heavy pressure in grinding and polishing must absolutely be avoided. Aluminum appears to be amorphized quite readily¹ and the production of a relatively thick amorphous surface layer is highly desirable. Hanson and Archbutt² claims that undue distortion may lead to difficulty in etching, since on etching in aqueous solutions the surfaces tend to become covered with a layer of "tarnish" which is troublesome to remove. The section to be examined should be carefully cut out with a hacksaw and then lightly ground flat. This preliminary grinding can be done either with a fine file or by holding the section against a revolving carborundum wheel or a wheel covered with moderately fine emery paper. After this procedure, the section is trans-

ferred to French Hubert emery papers of succeeding finenesses; viz., Nos. 0, 00, 000, 0000. These papers are preferably fastened to wooden blocks and the grinding done by hand. To prevent the emery particles from being forced into the surface of the section, the papers are covered with a film of paraffine or wax. The wax permits a high polish to be given to the section.

For final polishing several methods will yield good results. The writer prefers to polish by hand with a good metal polish on a smooth woolen cloth; the polish will remove the scratches from the No. 0000 paper, and the scratches from the metal polish can be eradicated by rubbing the section on another woolen cloth soaked in water. Final polishing can also be done by using fine tripoli before the metal polish, or by using levigated alumina instead of the metal polish. In any case, the polishing should be done lightly so as not to distort the surface unduly. Hanson and Archbutt³ say they secure excellent results by the use of magnesia powder on a rotating disk covered with a woolen cloth. The disk runs at about 500 r.p.m. They remove the fine scratches from the magnesia by polishing the section then on another disk well wetted with water. The selection of suitable cloth for polishing is very troublesome. The metal polish⁴ used by the writer has been previously referred to, and it has been found to be entirely satisfactory.

ALUMINUM INGOT

For commercial purposes, aluminum ingot is usually divided into two grades; viz., grade No. 1 and grade No. 2. The former contains 99.0 per cent aluminum and over, and the latter from 98.0 to 99.0 per cent. There are also some grades of lower aluminum content, and there is a considerable amount of secondary ingot turned over annually. For vital castings which must meet exacting specifications, the lower grades should not be used. The light-alloy casting industry is mainly concerned with the first two grades. Aluminum ingot appears on the market customarily in two forms; viz., 33-lb. 4-notch bars and 3-lb. 6-notch bars. In spite of the fact that aluminum ingot may contain over 99.0 per cent Al, the physical properties may be very variable. This matter has been definitely proved, and the subject will be more completely dealt with at a later date. The point to be made now is that the chemical analysis as ordinarily carried out is not a complete criterion of quality.

In fact, aluminum ingots of almost identical chemical composition have been found to possess such markedly different physical properties that the analysis has been doubted. The ordinary analysis calls for the determination of copper, iron and silicon, and the difference is said to be aluminum. As a matter of actual fact, this ordinary incomplete analysis is inadequate, gives only a su-

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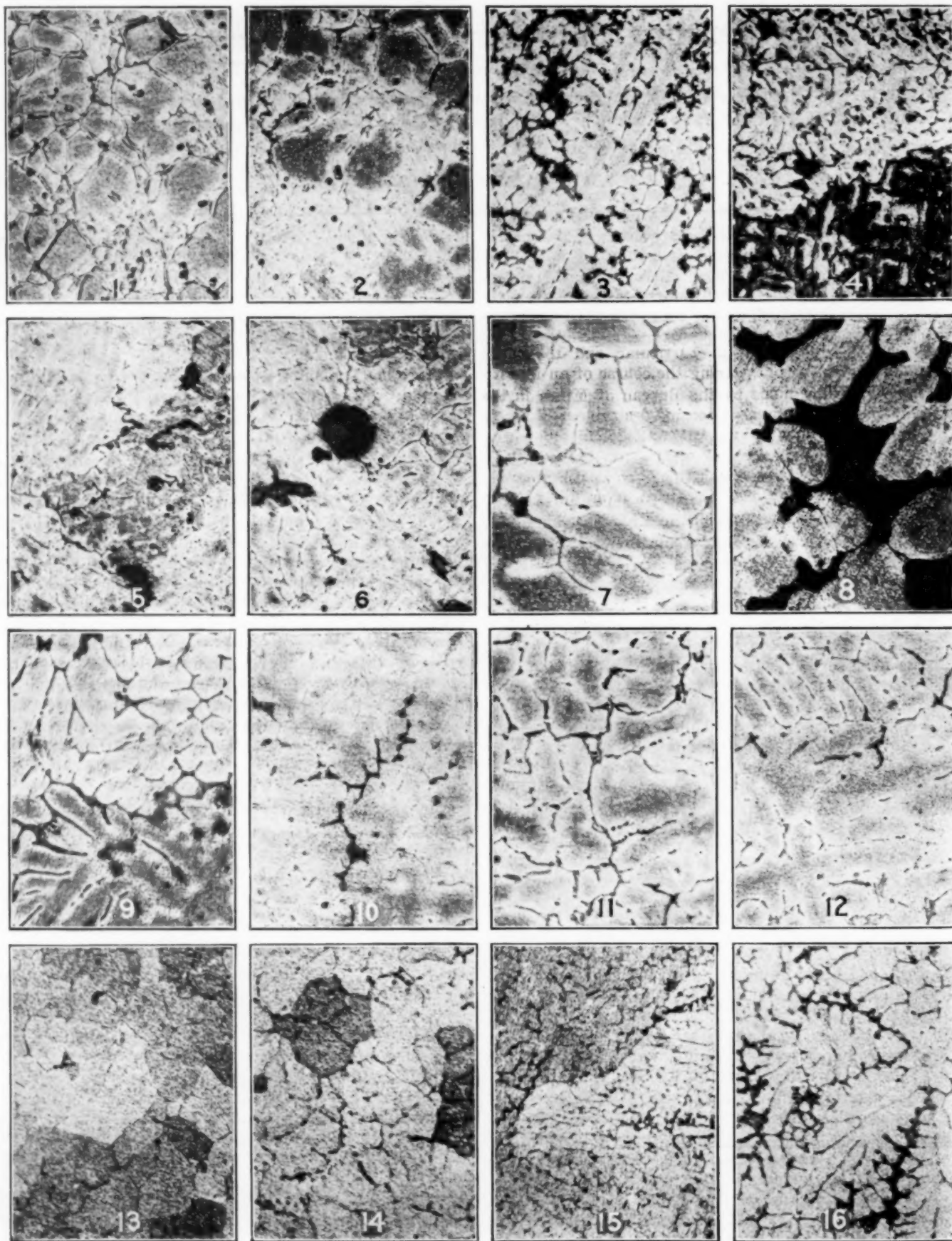
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¹Anderson, R. J., "The Metallography of Aluminum," *Journ. Frank. Inst.*, vol. 187, 1919, pp. 1-47.

²Hanson, D., and Archbutt, S. L., "The Micrography of Aluminum and Its Alloys," paper before the Institute of Metals (London), March, 1919; and the writer in discussion of this paper.

³Hanson, D., and Archbutt, S. L., *loc. cit.*

⁴Anderson, R. J., "Metallography of Aluminum," etc., *MET. & CHEM. ENG.*, vol. 18, 1918, pp. 172-178.



FIGS. 1 TO 16

Fig. 1—Sample 1; average structure. Fig. 2—Same as Fig. 1, but at another place. Fig. 3—Sample 2; average structure. Fig. 4—Same as Fig. 3, but at another place. Fig. 5—Sample 3; average structure. Fig. 6—Same as Fig. 5, but at another place. Fig. 7—Sample 20-1; center of microsection. Fig. 8—Same as Fig. 7, but near the piped edge; foreign occluded matter. Fig. 9—Same as Fig. 7, but at another place. Fig. 10—Sample 20-2; center of microsection; foreign occluded matter. Fig. 11—Sample 20-3; center of microsection. Fig. 12—Same as Fig. 11, but at the X edge. All $\times 75$. All etched with HF. Fig. 13—Sample 1; average structure. Fig. 14—Same as Fig. 13, but at another place. Fig. 15—Sample 2, average structure. Fig. 16—Same as Fig. 15, but at another place. Figs. 13 to 16 etched with NaOH; $\times 75$.

perficual idea of quality, and has been the basis of much fallacious reasoning. These and other matters in the metallurgy of aluminum are important and interesting, but the merest mention must suffice here.

MICROGRAPHY

Aluminum, being a metal of relatively low freezing point, has a quite large grain size; moreover, pronounced difference in microstructure may be found in different ingots of the same approximate chemical composition. Not only is that true, but marked differences in microstructure may be observed in various parts of any single ingot, and peculiar etching characteristics have been observed even in single microsections. Realizing the

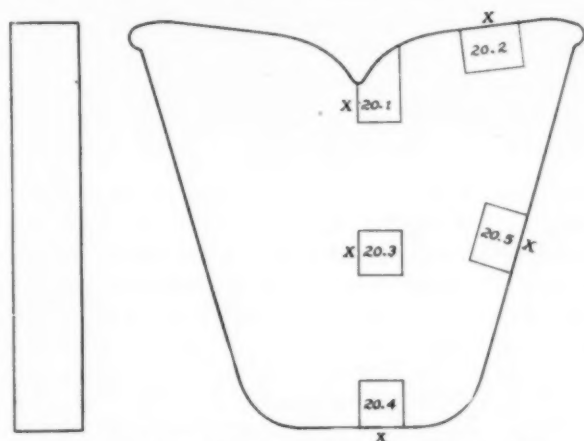


FIG. 17. SKETCH OF 33-LB. INGOT; CROSS-SECTION; HALF SIZE; SHOWING POSITIONS FROM WHICH MICROSECTIONS WERE CUT

significance of the facts just stated and taking into account the care which must be exercised in preparing microsections, it is not difficult to see that the correct interpretation of aluminum micrographs becomes a rather complicated affair. As has been pointed out previously by the writer, aluminum metallography is in its embryonic stage, and the metal has not yet been subjected to careful microscopic scrutiny by many observers. No doubt a metallography for aluminum will be evolved in time, and that will serve a useful purpose to the light-alloy industry.

To consider for a moment what the quality of aluminum ingot means to the foundries; the practical foundry-

man wants to know definitely whether the quality of the ingot has anything to do with the quality of the resultant alloy castings. There has unfortunately been a good deal of loose talk on this question; actual corroborative tests have been carried out in only a few isolated instances. For the present, it is sufficient to state that the quality of the ingot assuredly does have some influence on the quality of the resultant castings.

Turning now to a description of the microstructures of certain samples of ingot, reference may be made to Table I and to Figs. 1 to 16, inclusive. Fig. 1 illustrates the average structure of sample No. 1; this was a sample of good tough virgin aluminum. The microstructure is allotriomorphic, and the impurities unless in solid solution are mainly at the grain boundaries. Fig. 2 is the same section at another place; the variation in

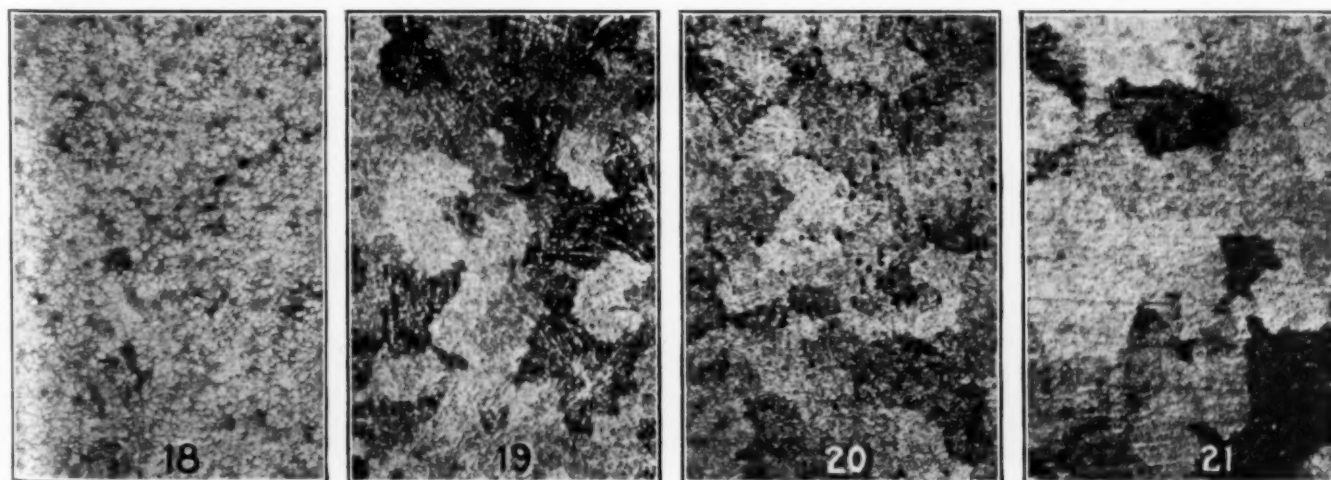
TABLE I.

Kind of Ingot	Physically Called	Sample Number	Chemical Composition				
			Cu	Fe	Si	Mn	Al*
Six-notch	Tough	1	0.16	0.37	0.33	Trace	99.14
Six-notch	Brittle	2	0.28	0.72	0.84	0.02	98.14
Six-notch	Brittle	3	0.18	0.40	0.38	0.04	99.00
Four-notch	Tough	20-1 to 20-5	0.20	0.57	0.18	.....	99.05

* Aluminum by difference.

microstructure within a single section is shown by comparing these two micrographs. Fig. 3 shows the structure of sample No. 2, and Fig. 4 is another micrograph of the same section. The differential etching of groups of dendrites and grains in sample No. 2 is also shown by Figs. 3 and 4, and this matter will be dealt with more completely in a later paragraph. Figs. 5 and 6 show the microstructure of sample No. 3. Samples Nos. 1, 2 and 3 were cut from the center of separate notches of 3-lb. 6-notch ingots. Examination was also made of sections cut from the webs of the same ingots, and the microstructures were reasonably similar.

In studying the microstructure of a 33-lb. 4-notch ingot, a section 0.75 in. thick was cut through one of the notches as shown in the sketch in Fig. 17 and the photograph in Fig. 22. The sketch indicates the various positions from which the microsections were taken. Fig. 7 shows the average structure of sample No. 20-1, while Fig. 8 shows considerable foreign occluded matter, pre-



FIGS. 18 TO 21

Fig. 18—Sample 1; average structure. Fig. 19—Sample 2; average structure. Fig. 20—Sample 3; average structure. Fig. 21—Sample 20-3; center of ingot. All $\times 7$. All etched with HF.



FIG. 22
Sawn section of 33-lb. ingot Samples 20-1 to 20-5 were taken from this section. Half size.

sumably aluminum oxide; the latter micrograph was taken at a point near the pipe. Fig. 9 gives another aspect of sample No. 20-1, and incidentally it also shows differential group etching. Fig. 10 is a micrograph of sample No. 20-2, showing intergranular occluded matter. Fig. 11 is a micrograph of sample No. 20-3. Fig. 12, also taken from sample No. 20-3, may be compared with Fig. 11 for the purpose of showing the variation in microstructure in different parts of a single microsection; Fig. 11 was taken from about the center of the section, but Fig. 12 was taken at a point near the X edge. Samples Nos. 20-4 and 20-5 were contiguous to the chill mold into which the ingot had been poured, and the effect of chill was to cause a tendency toward a dendritic structure on the X edge of these samples. Otherwise, the microstructures were not dissimilar to those already described for samples Nos. 20-1 to 20-3. All the above micrographs were of sections etched with hydrofluoric acid. A few micrographs of sections etched with sodium hydroxide are shown in Figs. 13 to 16 inclusive; these are self-explanatory and may be compared with Figs. 1 to 6 inclusive.

MACROGRAPHY

The examination of microsections of metals and alloys under low powers often yields very instructive results, and it has proved valuable in the study of aluminum ingots. For low-power examinations, the microsections were prepared in the usual manner, and after suitable etching were photographed. Figs. 18 to 21 inclusive are photographs at seven diameters of samples Nos. 1, 2, 3 and 20-3 respectively. Some idea of the relative grain size can be obtained from the macrographs. Those familiar with the interpretation of macrographs might assume that the differently shaded areas in Figs. 19, 20 and 21 are individual grains of large size. Microscopic examination, however, proves that this is not the case. Each of the presumed large grains is found to have a secondary internal structure, and is made up of a number of small grains or dendrites as the case may be. This brings the discussion to a consideration of differential group etching, but before dealing with that it will be better to consider first some other aspects of aluminum ingot; viz., surface appearance and fractures.

Ocular examination is useful in determining roughly the quality of aluminum ingot. In the foregoing, it has been hinted that the quality of ingot is rather variable

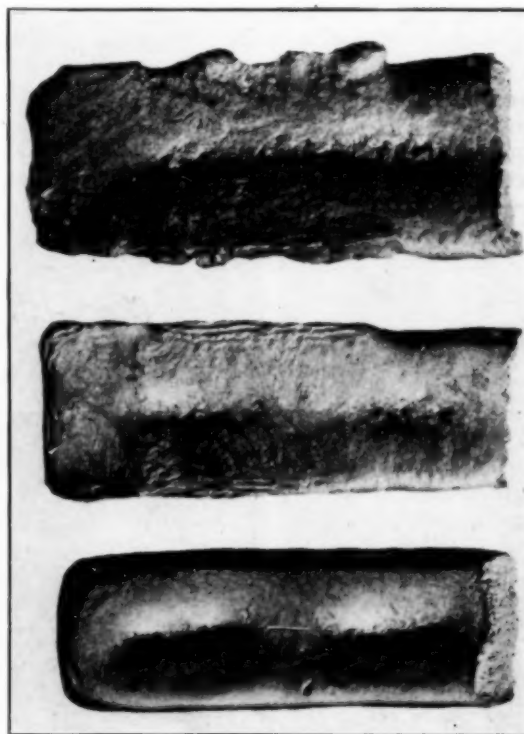
and that the physical properties may be quite different in ingots of approximately the same chemical analysis. In Table I, samples have been characterized as tough and brittle, and these terms are used to describe the behavior of the metal in tensile and bending tests. Without going into the matter in exhaustive detail, a distinction between brittle and tough ingot may be made. The tough ingot usually has greater ultimate strength, yield point, elongation and reduction in area than brittle ingot; further, the former will perform better in the bend test, where, for example, a 0.25-in. machined test piece, 2.0 in. long, is bent on itself. Tough ingot may bend 180 deg. and brittle ingot less than 90 deg. As to surface appearance, the brittle ingot is characterized by a rough, pebbly, whitish, frosted surface, and there may also be cracks in the webs pointing to hot shortness. Tough ingot, on the other hand, is smooth, bright and metallic in appearance. Photographs in Figs. 23, 24 and 25 show the upper surfaces of samples Nos. 1, 2 and 3.

FRACTURES

Fractures of aluminum ingot do not generally furnish interpretable data, but may be useful in some cases. Where fractures of patently brittle and tough ingot are compared, the former are characterized as coarse and the latter as fine. Fractures through the webs of samples Nos. 1, 2 and 3 are shown in Figs. 26, 27 and 28. Fig. 29 shows the fracture through one of the webs of the 33-lb. ingot from which samples Nos. 20-1 to 20-5 were taken. In the case of the fractures of samples Nos. 1, 2 and 3, these were effected by bending a 6-notch ingot through one of the center webs until fracture occurred. Sample No. 1 bent through practically 180 deg.; samples Nos. 2 and 3 broke off sharply at about 10-15 degrees.

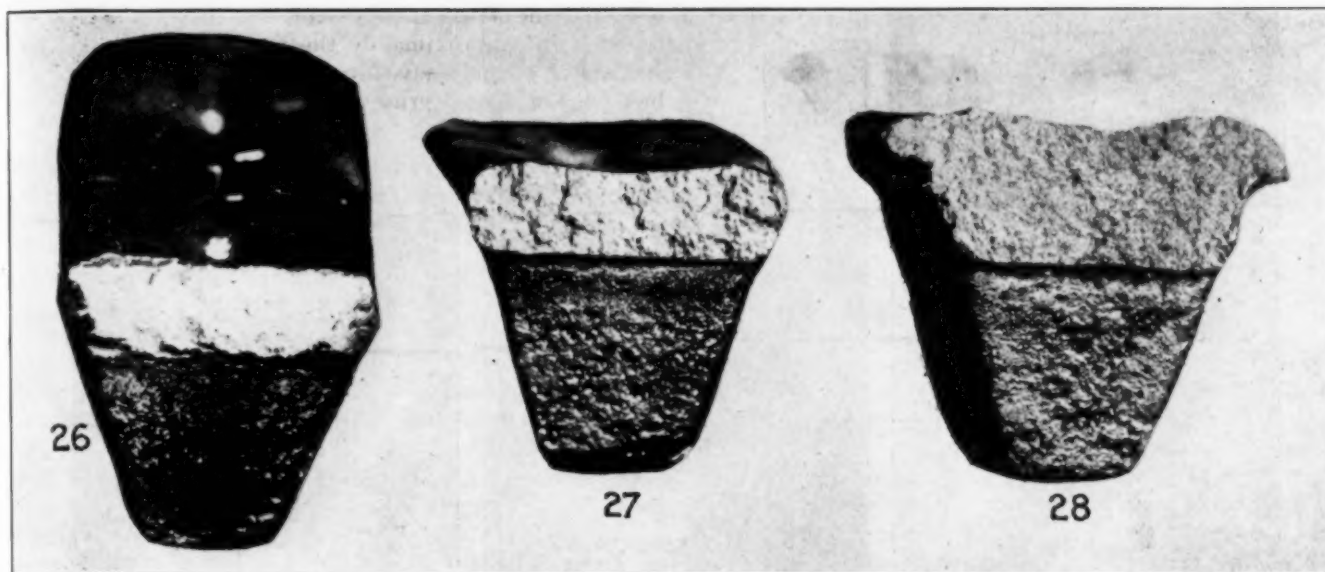
ETCHING REAGENTS FOR ALUMINUM

The most commonly used etching reagents for substantially pure aluminum are hydrofluoric acid and sodium hydroxide, both in aqueous solution. The con-



FIGS. 23, 24 AND 25

Upper surfaces of samples: 1 (upper); 2 (center) and 3 (lower)



FIGS. 26 TO 28

Fractures through the webs of samples 1, 2 and 3 respectively

centrations may vary widely within limits, but 5.0 to 10.0 per cent solutions of hydrofluoric acid and 10.0 to 20.0 per cent solutions of sodium hydroxide will be found most useful. When it becomes necessary to clean and brighten an etched surface, momentary immersion in concentrated nitric acid, sp.gr. 1.42, or in concentrated chromic acid is recommended.

CONSTITUENTS OF ALUMINUM

The common impurities found in aluminum ingot are copper, iron and silicon. Copper forms a solid solution with aluminum to the extent of several per cent Cu; iron forms the compound FeAl_3 , which is practically entirely insoluble in the solid state, and silicon occurs quite often as elemental silicon. Silicon and FeAl_3 can be distinguished from each other in unetched samples by the gray tone of the silicon as contrasted with the white of the FeAl_3 . They are more conveniently distinguished by etching with hydrofluoric acid, when the FeAl_3 will be seen dark and the silicon lighter. Sodium hydroxide also attacks FeAl_3 , but silicon appears to be attacked with difficulty by either of these reagents. Hanson and Archbutt⁵ have recently described methods for differentiating these constituents, and no further elaboration is deemed necessary here.

ETCHING CHARACTERISTICS OF INGOT

Differential group etching of aluminum has already been mentioned. This is shown admirably by the low power macrographs and better by panorama micrographs. Owing to the large amount of space necessary to reproduce a panoramograph, it is not considered advisable to attempt to show one, but a short description will be given and a few selected single micrographs shown. As stated above, it might appear from a cursory examination of the macrographs in Figs. 18 to 21 inclusive that each differentially etched area represents a single grain or possibly two or three grains oriented nearly the same. On the contrary, this is not so at all; as a matter of actual fact, each presumed large grain has a secondary structure and is made up of numerous smaller grains or dendrites. This group etching of grains has also been observed in some aluminum alloys as well as in substantially pure aluminum. It seems that

each group of grains which reflect light similarly into the tube of the microscope is similarly oriented while those of a neighboring group are differently oriented. This means simply group orientation of grains, the orientation changing from group to group. Whether this is actually so or not is not known to the writer, but it would appear to be.

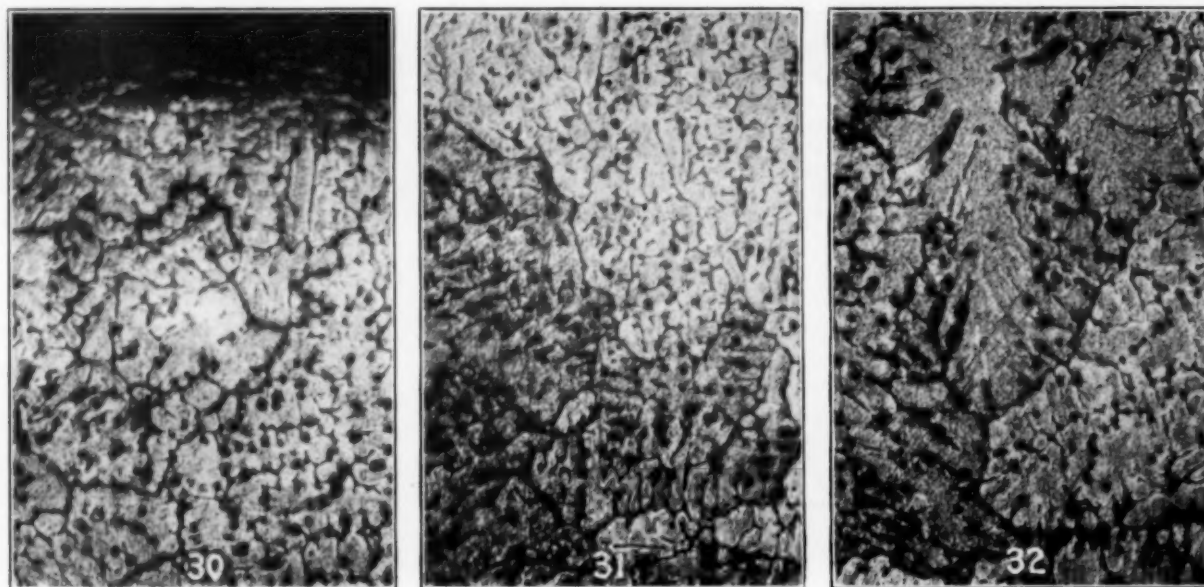
The phenomenon may be observed fairly well in micrographs. In Fig. 14, there is a group of four grains reflecting the same amount of light, surrounded by grains reflecting different amounts of light. In Fig. 15, the line of demarcation from one group dendrite to another can be plainly seen. Other micrographs, Figs. 4, 5 and 9, also illustrate this feature. For the time being, the phenomenon may be referred to as "differential group etching" for want of a better descriptive title. Figs. 30, 31 and 32 are micrographs of sample No. 2 after fairly deep etching with hydrofluoric acid. These are at different positions on the microsection. When properly fitted together and matched, a series of photomicrographs across the entire surface of a microsection gave a sort of panorama of the surface from edge to edge.



FIG. 29

Fracture through one of the webs of 33-lb. ingot from which samples 20-1 to 20-5 were taken. Half size

⁵Hanson, D., and Archbutt, S. L., *loc. cit.*



FIGS. 30 TO 32

Fig. 30—Sample 2, at edge. Fig. 31—Same as Fig. 30, but at another place. Fig. 32—Same as Fig. 30, but at another place. All $\times 75$. All etched with HF

Now, with regard to an explanation of the differential etching, it is the opinion of the writer that a possible tentative explanation may be as follows: When aluminum freezes, it normally freezes so as to form relatively large grains of the approximate size indicated by the groups. With no impurities present, the large grains would represent the true grain size. All the crystalline aluminum, surrounded by its amorphous phase together with part of the impurities, in any one so-called group is oriented the same throughout; all the crystalline aluminum in the next adjoining group is oriented differently. Part of the eutectic-forming impurities are not rejected to the boundaries of the large grains represented by the groups, but are scattered through each large grain. At the moment of final freezing, i.e., when the temperature is so low that no impurities can be liquid, these impurities freeze in position (wherever they happen to be) and thus give rise to a structure within each large grain. Where the impurities form a continuous network, they give rise to smaller grains, and where they are discontinuous, they result in the formation of stringers. The same argument applies to the different orientation of groups of dendrites. An objection which may occur to some is that the phenomenon may be simply due to a stain or tarnish on the surface; this cannot explain the case, because no stain would follow grain boundaries sharply, but would appear as an indiscriminate pattern.

International Union of the Associations of Pure and Applied Chemistry

The Interallied Chemical Confederation, which was organized in Paris last April, held its second meeting in London July 14-18. At this meeting the delegates were:

Belgium—R. Lucion, ex-president of the Société Chimique de Belgique; J. Timmermans, professor at the University of Brussels.

France—A. Behal, Member of the Academy of Medicine, professor Ecole Supérieure de Pharmacie; J. Gerard, chemical engineer, general secretary of the Société de Chimie Industrielle; P. Kestner, president of the Société de Chimie Industrielle; Ch. Marie, general

secretary of the Société de Chimie Physique; R. Marquis, editor of the *Bulletin de la Société Chimique de France*; Ch. Moureu, president of the Interallied Council, and of the French Federation of the Chemical Associations, professor at the Collège de France.

Great Britain—F. Frankland Armstrong, member of the Council of the Society of Chemical Industry; Henry Armstrong, emeritus professor of chemistry in the Imperial College of Science and Technology, past president of the Chemical Society; A. Chaston Chapman, past president of the Society of Public Analysts; Henry Louis, professor of mining and metallurgy in the University of Newcastle-on-Tyne, past president of the Society of Chemical Industry; Sir William Pope, professor of chemistry in the University of Cambridge, chairman of the Federal Council of Pure and Applied Chemistry, past president of the Chemical Society; W. P. Wynne, professor of chemistry in the University of Sheffield, president of the Chemical Society.

Italy—G. Pirelli of the Society of Chemical Industry, Milan; Dr. Severini of the General Cyanamide Society.

United States and Canada—Frederick Cottrell, chief metallurgist U. S. Bureau of Mines; Prof. Charles L. Parsons, chief chemist U. S. Bureau of Mines, secretary of the American Chemical Society; Edward W. Washburn, professor of ceramic chemistry, University of Illinois; Robert J. Ruttan, director of department of chemistry, McGill University, Montreal, president of Royal Society of Canada, member of Advisory Council for Scientific and Industrial Research.

The meeting was devoted to the detailed elaboration of the policies and aims of the confederation.

It has been decided that the official name of the Confederation shall be henceforth "Union Internationale des Associations de Chimie Pure et Appliquée" (International Union of the Associations of Pure and Applied Chemistry), and that the provisory business address shall be 49 Rue des Mathurins, Paris.

The following officers were elected: President, Prof. Moureu; vice-presidents, Chavanne, Parodi Delfino, Charles L. Parsons and Sir William Pope; general secretary, Jean Gerard.

The next meeting will be held in Rome in June, 1920.

¹See CHEM. & MET. ENG., Vol. 20, No. 11, June 1, 1919, p. 561.

The Design of Electric Furnaces

Consideration of the Elements of Size and Other Details in the Relation to Operation and the Recovery of Metal, With Special Reference to the Production of Ferromanganese

By R. C. GOSROW

A CERTAIN article in the Dec. 1 issue of CHEMICAL & METALLURGICAL ENGINEERING referring to the size of ferromanganese furnaces, and the relation of size to manganese recoveries¹, touches a subject which is a principal factor in the successful and profitable electric smelting of manganese ores. Such ores may be carbonate, oxide or silicate ores of manganese. Successful and profitable electric smelting refers to the production of a useful alloy of the iron-manganese series for steel manufacture, and other uses; and obtaining sufficient recoveries of the metal from the raw ores as to give a reasonable margin of profit on the operations, from the marketing of the alloy. By any method of obtaining increased recoveries of metal from the ores, it is reasonable to anticipate increased returns from the operation.

The subject first referred to has been so stated that a certain "size of furnace" is considered to be an important factor in obtaining increased recoveries of metal from ores. This is undoubtedly very true, but ambiguous. "Size of furnace" must consider three physical dimensions primarily: length, width, depth. Or more strictly speaking, "height of ore column" should be used in place of "depth." "Size" may imply cubical volume, also any component which may be a factor in its volume. It may also suggest the electrical capacity in transformers connected to the furnace; or it may mean the alloy or metal output. Thus it may be seen that "size" of furnace is rather a meaningless expression.

Two furnaces may have exactly the same cubical contents. One may have a variable in some component of its cubical measure, as compared with the other, and yet both furnaces will not operate efficiently on the same voltage, or respond equally to the same charge. The two furnaces may not develop the same conditions during operation; will not carry the same load; will not operate equally well on the same or equal voltages; and will not produce the same slags, or metals, according to the analytical comparisons. Neither will each furnace produce the same tonnage, providing both have equal electrical connected capacities. I mention these points initially to outline the absolute necessity of analyzing and comparing each dimensional component of the furnace design, and not merely to take the summation or product of all dimensions, and alone compare smelting operations on furnaces of equal holding capacity, or of equal electrical connected capacity.

RELATION OF FURNACE SIZE TO EFFICIENCY

In paragraph 1 of the article referred to, on page 749, the author states that "observation of a number of electric furnaces, varying considerably in size and

transformer capacity, and all working under the same conditions, shows the small furnace to be much more efficient in operation than the large furnace."

After reading the above statement, the question one would ask is, "Why is the small 'size' of furnace more efficient in operation?" Is the efficiency referred to rated on the kilowatt-hour consumption per ton of metal of standard content produced, or on manganese recovered in the alloy? It may be both. A low kilowatt-hour consumption may go hand in hand with a high recovery of metal, and vice versa. A low recovery of metal means larger slag volume and greater tonnage of ore to be put through the furnace to keep up the production, increasing power consumption considerably per ton of salable alloy produced.

ADVANTAGES OF "SMALL SIZE" FURNACE

As the "small size" furnace is more carefully charged than the "large size" furnace, the charge may be better distributed over the top area of the furnace, and be given more stoking, if such be necessary. As the charge is weighed in less quantity, more careful weighing may be accomplished. Also with the lesser weights of charges, and mixing of charge ingredients, errors in weighing cause greater fluctuations in smelting operations.

Usually mechanical features of strength require greater electrode areas than the actual load requirements of the furnace would specify. This means better heat distribution, and less current density in the electrodes, with less voltage drop in the electrodes. By increasing electrode areas, increased water cooling in the holders may be accomplished, directly keeping the electrodes cooler above the charge line.

As the "small size" furnace can be better manipulated, a faster furnace results, with increased efficiency and economy in operation over a slower furnace. With a small crucible the furnace may be more thoroughly drained of metal at taps, and slag and carbide accretions controlled and readily removed.

The remarks here made that are relative to a comparative "small size" of furnace do not in any way validate these points and establish them. Frequently operations cannot bear a number of small units and their increasing number alone would eliminate them as a commercial factor. Larger units in equipment frequently solve a problem not only of metallurgy but of finances. Larger units where successful are much desired to small units.

CAN LARGE FURNACES BE EQUALLY EFFICIENT AS SMALL?

The question may now justly be put, "Why cannot the 'large size' furnace be equally efficient, metallurgically, electrically and from a dollars-and-cents viewpoint, as the 'small size' furnace?"

It must be considered that, "large" and "small" being

¹"Size vs. Recoveries in Ferromanganese Furnaces," E. S. Bardwell, CHEM. & MET. ENG., Vol. 19, No. 11, p. 749, Dec. 1, 1918.

comparative adjectives, it would be more to the point to describe two furnaces for comparison as being "twice the length," "one-half the depth of ore column," "one-third the width," "one-quarter the volume," etc.; these statements then being based on any dimensional component of the furnace volume: its electrical equipment, electrode sizes and areas and their relation to furnace crucible area, the rate of power input, and metal production, etc.

During the past eight years the writer has been actively and intensively engaged in the electric smelting of manganese, silicon, chromium, tungsten and molybdenum ores for the production of their ferro-alloys, also the electric smelting of iron ores for basic and foundry pig-irons, and has continually made a careful study of the furnace conditions on each, endeavoring to determine those factors which under some instances gave failures, while in others marked success. These conditions were encountered when smelting the various ores and in various designed and proportioned furnaces, with varying electrical capacities. I use the term "proportioned" in preference to "size." It was demonstrated that the proper proportioning of the several dimensions of a furnace, to do certain reduction work on ores by electric heating, must be determined by careful study and observation, and one must build the furnace and equipment into those conditions which exhibit themselves during operations.

E PERIENCE WITH A LARGE FURNACE

I desire to narrate an experience while operating two 15-ton rated ferromanganese furnaces in 1914. The one furnace was constructed after an ideal, or rather a dream. I use the term "constructed" because the furnace was not "designed," but the structural details were drawn up and the job assembled, with the result that there was on the ground a steel shell brick-lined, electrodes and holders, buses and transformers, and a great variety of electrical paraphernalia. The furnace was erected when I arrived, and it was ready to operate.

The furnace shell was made of $\frac{3}{8}$ -in. steel plating, heavily reinforced and braced, and was a good piece of work. The shell measured 27 ft. inside in its length, with curving side walls 12 ft. across at the center, and 10 ft. at the ends; and from the bounding angle around the top of side and end wall plates to the bottom plate approximately 12 ft. 6 in. This was indeed a tank. An 18-in. brick lining was put in all around and an 18-in. bottom. This lining and bottom in the shell gave a crucible of 24 ft. by (average) 8 ft. by 11 ft., having a cubical volume effectively filled with charge of 1900 cu. ft. The four electrodes were 12 in. in diameter Acheson graphite, with threaded cone joints. The transformer installation consisted of six 750-k.v.a. single-phase General Electric transformers, two on each phase connected in parallel. Copper buses and electrode holders were sufficient for maximum loads carried. The electrical equipment on this installation was well laid out, and caused no interference, but it was not possible to get any good measure of this electrical capacity into that furnace full of charge material.

This furnace was considered a "large" size furnace. From the standpoint of smelting capacity it was a "small" size furnace. Here we have two "sizes" for the same furnace, each dependent on particular features of design, production and the ratio of certain component parts to one another, but such statements are vague and ambiguous when speaking of "size."

I wish to analyze some of the details of this furnace:

L—Length inside lining.....	24 ft. 0 in.
W—Width inside lining.....	8 ft. 0 in.
D—Depth of ore column.....	10 ft. 0 in.
V—Cubical contents crucible (effective).....	1920 cu.ft.
A—Crucible area.....	192 sq.ft.
E—Electrode area.....	3.14 sq.ft.

Existing ratios of components:

$\frac{L}{W}$	3 to 1
$\frac{A}{E}$	61.2 to 1
$\frac{D}{W}$	1.25 to 1

Voltage normally carried in buses.....	80 volts
Max. load carried in furnace any time.....	1,800 kw.
Max. load carried per cent of total time.....	11 per cent
Approx. current at 80v., 1800 kw., 0.85 p.f.....	19,100 amp.
Approx. current per middle phases.....	11,000 amp.
Approx. current per end phases.....	5,500 amp.
Approx. current per cubic foot of charge.....	10 amp.
Electrodes connected in delta.....	
Production: three tons per 24 hr.....	

From the above figures we may note, the furnace, filled 90 per cent of its effective volume with charge, amounts to 1900 cu.ft. Then from power input we may calculate 10 amp. per cu.ft. of charge, or approximately 10 amp. per 180 lb. of charge. If it were possible to distribute evenly the heating effect of this current throughout the furnace, it can be readily appreciated that a minimum amount of work would be done. The net result would be small volumes of fused charge probably reduced near the electrodes, and large volumes of unfused charge, not melted or reduced, spread throughout the volume of the charge at low levels in the furnace. This anticipated result was verified. In proximity to the electrode tips high temperatures were developed. As the furnace hearth was conducting, the path of least resistance to current flow was straight down to the bottom, consequently rapid and excessive heating occurred in the areas directly under and around the ends of the electrodes. It was therefore only possible to carry loads (electrical) when fused and reduced material made contact between the electrodes and the furnace bottom. The electrodes were spaced 66 in. center to center. This apparently was too great a distance, at the then operating voltage, for a continuous passage of current from one electrode to the next, and to provide a continuous heated path for current to pass from one phase to the next, to give proper phase balancing, and also to develop the temperature for smelting. The conditions, then, represented a molten pool under each electrode, contact with the hearth, passage of current to the next pool through the hearth and to the electrode, completing the circuit as the current travel may be. But areas midway between the electrodes were cold, semi-fused non-conductors, and insulated each electrode, electrically and thermally, from the next.

THERMAL INFLUENCE OF THE ELECTRODE

Here, then, was a phenomenon exhibiting the heating influence which an electrode has over an area affected by it. In order to classify and distinguish this phenomenon I have termed it the "thermal influence of the electrode." I would define the expression as being the effect of the current at the electrode and contact, and the influence which the electrode has in distributing this heat to a surrounding area. This may be determined experimentally for any voltage range, with any nature of materials constituting the charge, and for any power loads, but depends principally on the voltage between the electrode and the charge or the hearth, and the nature of the charge, electrically and physically. With furnace conditions so abnormal that only light and uncertain loads could be maintained in the furnace,

and a low ore column being necessary, the loss from volatilization was certain to be high. Figures from periodic capitulations showed slag and volatile losses of manganese to run from 22 to 32 per cent. These figures show very poor recoveries compared to others on the same ores. The reasons therefor are apparent.

INEFFICIENCY DUE TO IMPROPER PROPORTIONING

The various related dimensions of this furnace lacked the proper proportioning to develop the best efficiencies in the operations. As the results aimed for by a proper mixing of the charge were lost, due to the frozen areas in the furnace, the proper reductions did not take place, accounting for the high manganous oxide content in the slags. Some of the slags ran as follows:

MnO Per Cent	CaO Per Cent	SiO ₂ Per Cent
28.0	38.7	28.3
22.3	37.9	30.8
27.4	35.1	29.3
27.0	28.5	36.1
24.0	35.8	33.5

These represented weekly averages, and running on irregular operations. These erratic smelting conditions caused high volatile losses, running as high as 9 to 14 per cent. But volatile losses may be controlled only to a moderate figure. It is not possible to reduce them to zero. This furnace was run for 8 days only, and produced 24 tons of 80 per cent ferromanganese alloy. The recovery was 62 per cent of metal. Maximum load for 11 per cent of the time was 1800 kw. Eighty-eight tons of manganese ore averaging 44 per cent Mn and 18 per cent SiO₂ were smelted. This was a "large" size furnace in all respects except production and power input. It had large dimensions only. But this was not its real and only fault. The real and primary cause may be attributed to the design and lack of care and attention to the proper proportioning of its component parts. Such an inefficient piece of apparatus makes a poor but effective comparison.

The second furnace was of similar constructional details, but in its design there were incorporated those metallurgical principles of detail which the apparatus was required to carry out. Careful attention was given to the details of properly proportioning those component parts which were to make up the furnace. It had developed in my experience to regard carefully certain essential ratios in furnace details as all important in the design. I had also observed the effect of electric heating in straight resistance type ore smelting furnaces, and had learned to appreciate the effect of heat caused by the current from one electrode, and heat caused by the current from an adjacent electrode. This particular relationship as before mentioned I have termed the thermal influence of the electrode. This heat influence may be large or small depending of course on the voltage drop between the electrode and the charge or the furnace hearth, the power input and the nature of the materials in the charge. As the mathematical value may be expressed in terms of the electrode diameter, this is primarily a factor. From the value of the thermal influence of the electrode, under certain conditions, we may find a value representing the ratio of electrode area to area of furnace crucible.

AREA OF THERMAL INFLUENCE OF ELECTRODE

To illustrate this statement: It has been determined by observation and measurement that the area of thermal influence of a 12-in. diameter graphitized electrode in an ore smelting furnace, running at 60 v. on

the buses, 1800-kw. load, could be represented by the formula:

$$AT = \frac{(d \times a)^2 \times 0.7854}{144}$$

in which

AT equals sq.ft. area of thermal influence of the electrode.

d equals electrode diameter in inches.

a equals a constant; depending on voltage, nature of materials in the charge, etc. For manganese, chrome, and iron smelting this value has been found to be 2.5 to 2.75, and using graphitized electrodes.

The diameter of the area of thermal influence may be also found by:

$$DT = \sqrt{\frac{AT}{0.7854}}$$

Considering the plane of the thermal influence area to be horizontal, it is now possible to determine the proper spacing of the electrodes, and also to fix the area of furnace crucible and the ratio of furnace area to electrode area. We now have a starting point for assembling the several factors entering into the design of the furnace. As the energy consumption per ton of product, and desired production must be known, these factors must be balanced against the former for electrode area and furnace crucible area. The proper spacing of the electrodes is an important feature and directly concerns efficiency of operation in any "size" of furnace. It is primarily essential to have a furnace operate with a cool top and a hot hearth. To obtain this the electrode spacing must be such as to utilize the thermal influence of each electrode at the plane of electrode contact, in the smelting zone of the furnace. Also the electrodes should be sufficiently far apart to increase, as far as possible, furnace capacity for charge. They must also be properly spaced to eliminate any "jumping across" of current from one electrode to another in the upper part of the furnace and in the unsmelted portion of the charge. By considering these factors, electrode spacing will be ultimately fixed.

EFFECT OF DEPTH OF ORE COLUMN

The proper depth of ore column and length of electrode to carry are very important factors, often given little thought and consideration, because their causes and effects are not understood. Many furnaces which I have examined and studied showed no reasons for making these dimensions as they were. The proper depth of ore column must bear a definite relation to the material being smelted and to the metal produced. The height of ore column directly bears the same relation. In smelting chrome and manganese ores lower ore columns are used than are in smelting iron ores. This is due to the difference in reducing reactions and slag purifying of the metal; also in manganese and chrome smelting no well of metal is maintained as in iron smelting.

In the electric smelting furnace, reducing gases are not depended on or utilized for ore reduction in the descending column. But as reduced gases are not utilized for reduction long ore columns are not necessary, and also too short ore columns are not desired. But in the "small" capacity furnace operated by hand, shorter ore columns may be used, because the accumulation of heat on the hearth is not so great as in the "larger" mechanically operated furnaces. We must also be guided by

the mechanical strength of carbon and graphitized electrodes, and the economy of carrying average lengths of either in the furnace.

The depth of ore column may not always be determined solely by metallurgical conditions. The designer may desire to carry a height of ore column inconsistent with strength of electrodes or length of electrodes obtainable from the manufacturers. He must be guided by a combination of conditions.

In the case of graphitized electrodes, good mechanical joints may be made and a joint having at least 85 per cent of the strength of the solid body of the electrode may be obtained. This refers to transverse strength of the joint and the material. Ungraphitized carbon electrodes do not exhibit such good mechanical properties in the joints. The pressure of the charge against the electrodes and the movement in the charge largely determine length of electrode, by gaining the requisite mechanical strength.

RELATION OF FURNACE DESIGN TO LIFE OF REFRACTORY LINING

A most important subject to a smelter is usually linings, pertaining to the life of the refractories in the furnace. The proper design of furnace has considerable effect on refractories, and we have another important component of furnace design. It is the distance from the front and back walls of a furnace to the electrodes (considering the electrodes in a straight line with the furnace long axis). This proper proportioning calls for a close study of past furnace operations on various loads, metals, ores, charges and rate of smelting. My experience has shown that a furnace inner-wall-line should be just close enough to the electrodes as to allow charge to fuse on its surface, but yet be far enough from the electrodes to interfere with fluxing or melting of the wall refractory. This may be controlled to a large extent by using water-cooled wall plates so that the fusing may be stopped by the rapid conduction of heat as soon as this condition is approached. In ferrochrome smelting this practice is of considerable benefit in maintaining the linings. The bad results of having the walls too far away are also numerous. The bad results may be exhibited by a cold tap-hole; running of the unfused charge into the tap-hole at time of tapping metal; inactive charge in the furnace not working down and being smelted, causing scaffolds and hangups; excessive heating of the one wall. On the side of the furnace from which tapping is done, the cooler wall conditions should result from the unfused charge constantly moving on this wall and the charge being shifted when tapping of metal takes place. On the other hand, it may also be the hotter wall, because the hot charge would follow the flow of metal, which would run to the tapping hole or notch. The opposite wall, then, would now exhibit the hotter conditions due to the charge lying dead on this wall.

If the imagination may be used, we can say the following conditions exist: As before stated, each electrode has a certain area over which its heating influence is exhibited. Consider three or four electrodes in a straight line, along the long axis of the furnace shell. Consider the thermal influence areas to be circular or nearly so, as the electrode is circular. We would then have under proper conditions three or four circular (or nearly so) areas, tangent to or interlocking one another; in other words, a hot area continuous through the center of the furnace, due to overlapping of heated areas.

As the thermal influence areas also extend at right angles to the long axis of the furnace, its effect is extended to the front and back walls, and tangents to such areas would be the wall line. The width of the furnace may be so determined, and the ultimate results on the wall refractories may be determined. It must not be considered that the location of front and back walls from the electrodes is as vitally important along the top of the charge. Here no fusion or reduction takes place, but the plane of proper fixing of these distances is in the fusion zone only. But, as will be mentioned later, straight walls are desirable, and not walls giving enlarging or reducing forms to the furnace shell.

DETAILS AND PROPORTIONS OF ANOTHER FURNACE

This second furnace was designed with the consideration of points such as those previously mentioned. It was a "large" size furnace, in cubical volume, in smelting capacity, metal production and power input. I desire to attach some of its details and proportions:

L—Length inside of lining.....	15 ft. 6 in.
W—Width inside of lining.....	7 ft. 6 in.
D—Depth of ore column.....	7 ft. 10 in.
A—Area of crucible.....	116 sq.ft.
E—Area of electrodes (4, graphitized).....	3.14 sq.ft.
V—Cubical contents (charge).....	908 cu.ft.

Existing ratios of components:

$\frac{L}{W}$	2.07 to 1
$\frac{A}{E}$	37.0 to 1
$\frac{E}{D}$	1.04 to 1

Voltage normally carried on buses.....	60 volts
Max. load 95 per cent of the total time.....	1,650 kw.
Transformers, 3 750 k.v.a., delta connected.....	Single phase.
Approx. current at 80 v., 1650 kw., 0.88 p.f.....	24,000 amp.
Approx. current per middle phases.....	14,000 amp.
Approx. current per end phases.....	7,000 amp.
Approx. current per cu.ft. of charge.....	27 amp.
Approx. current per 100 lb. of charge.....	27 amp.

Production: 16 tons 81.5 per cent Mn ferromanganese alloy per 24 hr.

REPRESENTATIVE ANALYSES OF ORES SMELTED

Oxide and Rhodonite Ores.	On Dry Basis	Per Cent
Manganese (metallic).....	40 to 51	
Silica.....	24 to 10	
Manganous oxide.....	16 to 9.5	
Manganese dioxide.....	52 to 68	
Ferrous oxide.....	3 to 1.75	

SLAGS PRODUCED

High and low manganese contents		
MnO	SiO ₂	CaO
16.3	36.0	41.3
13.55	35.4	44.3
12.1	36.8	44.6
14.3	36.0	44.4
14.4	42.0	40.2
14.25	39.0	41.9
11.8	37.2	45.1
14.6	36.8	41.7

The metal account over a 90-day period showed:

	Per Cent
Manganese in the alloy.....	79.55
Manganese in the slag.....	15.65
Manganese in dust and volatile losses.....	4.80
	100.00

EFFECT OF DESIGN ON HEAT CONCENTRATION

This second furnace, then, both in features of design and in operation, was much superior to the first one. The current density if evenly distributed throughout the furnace calculates to 27 amp. per cu.ft. of charge, while in the first furnace this value showed only 10 amp. This figure, while not being of any great value in this significant use, means considerable when it is considered that every cubic foot of material is acted upon by about two and one half times the current and heat that the first furnace shows. These values must not be taken in their mathematical value, but in their indicative terms. It also gives a fair value for the comparison of two fur-

naces, to arrive at a relation for heat input. In the second furnace there was accomplished a greater concentration of heat, rather than a greater distribution of heat. The value for current density interprets this condition. Even heat distribution and also heat concentration may be accomplished with the proper design of the apparatus and proper proportioning of its component details.

The conditions governing voltage ranges in an ore smelting furnace are not a direct comparison to those encountered in the steel furnaces using arc and arc-resistance heating. The smelting furnace here referred to uses both arc and arc-resistance for the generation of its heat. It may be desired to change the voltage during the operations; this would necessitate variable voltage regulation on the transformers; or it may be desired to use a fixed voltage on the transformers and vary the resistance in the furnace. The subject of the proper voltage for best recoveries and proper operating conditions does not appear to be the question to settle. The question appears to be: With any voltage on the secondary side of the transformer, within reason of the points previously referred to on this subject, what are the conditions which can be obtained to get the best results from the given voltage? The matter of a few volts variation is nothing here nor there. Usually an approximate voltage is determined on to build the equipment to, often determined from some past experience, etc. It is not necessary to pay great attention to voltage range, and to spend large sums of money to build special expensive equipment to get a certain desired voltage. This may and can be taken care of by other means, and the subject of adjusting the furnace conditions to a transformer's secondary voltage may be taken care of. This of course refers to the moderate and not the extreme.

INFLUENCE OF REDUCING MATERIAL USED

In using the various reducing materials—coal, coke, charcoal, petroleum coke, gas carbon briquettes, etc.—and using any one of them in a range of sizes from $\frac{3}{4}$ -in. up to $2\frac{1}{2}$ -in. ring size, it will be noted that a varying set of conditions exists for varying size of the same material and for each different material. To eliminate unnecessary repetition here, I refer to my article on "Coke as Reducing Agent in the Electric Smelting Furnace," METALLURGICAL & CHEMICAL ENGINEERING, Vol. 14, No. 12, June 15, 1916, Page 691 et seq. Here only two reducing agents are compared, coke and charcoal. But the conditions produced by the use of any of these materials bear directly on furnace operations. Such conditions may be defined as varying voltage by varying the resistance, power efficiency in the furnace, and recovery of metal in the alloy, and manganese content in slags.

It might be stated here that a transformer with the voltage ranges 30-60 or 30-60-90 would meet all requirements on a smelting furnace. A fixed voltage may be used on the secondary buses, and internal resistance of the furnace varied. By a change in the reducing material used, a change in the nature of the charge may be effected, consequently a change in the electrical characteristics of the charge is effected. Also a change in the size of the material effects a change in the electrical conditions.

In one furnace producing ferromanganese, fine coke (1 in.) continually produced carbides, while coarse coke ($2\frac{1}{2}$ in.) gave good reductions and produced a minimum of carbides in the slag, with increased alloy production. Lump charcoal also promoted better conditions. In an-

other instance in producing foundry-pig, 1-in. coke made good foundry-iron ($2-2\frac{1}{2}$ per cent silicon). When using coarse $2\frac{1}{2}$ -in. lumps, a low silicon pig resulted, under 1 per cent silicon. These operations took place in making electric furnace pig iron on 30-ton furnace operations direct from ore in the furnace. The component details of furnace design also played a large part here, as the electrodes were probably too close together, allowed a large part of the current to jump across, and made the furnace top very hot. The fine coke did not exhibit these details, but it caused a very hot furnace and caused the formation of considerable carbide in the bottom of the furnace. These carbide accretions soon built up and caused hang-ups, with the result of burning out side and end walls. Water cooling was resorted to, and while it made considerable difference on the side walls, did not help the interior of the furnace. One reason for the accumulation of these accretions at the point where they did occur was a contraction in the area of the furnace, causing excessive heating to a small volume of charge here and producing compounds of high heats of formation. Restrictions in shape and dimensions are bad features in an electric furnace and should be avoided unless for vital reasons.

COKE AND CHARCOAL IN DEEP AND SHALLOW FURNACES

In two different furnaces running on ferromanganese, having the same bus bar voltages, same ore and reducing material, neither furnace had the same height of ore column, or the same spacing between electrodes. The deeper furnace—9-ft. depth of ore column, 60-in. spacing of electrodes—worked better on coarse coke. The other furnace—7-ft. depth of ore column, 40-in. electrode spacing—worked better on coarse charcoal. From my article referred to this becomes apparent. The shallow furnace worked well on 1-in. coke, while the deeper furnace could not be run on 1-in. coke. By increasing the voltage on each furnace and connecting the deeper furnace in star, the only alternative was a higher ore column. With higher voltages, my opinion leads to the use of higher ore column. Higher ore column means more electrode length to carry, with increased breakages. I once decided to investigate the relation of voltage to electrode breakage, and now believe that high voltage meant high ore column and consequently more electrode breaks. Undoubtedly the resistance of electrode material has something to do with electrode weakness, but in such conditions as an electrode smelting furnace runs under, this would be a minor cause.

Another point which has considerable bearing on furnace operations and recoveries is the method of charging the furnace. As referred to in the beginning of this article, a furnace controlled and worked entirely by hand can be more easily charged than a furnace requiring mechanical appliances for loading and charging. This is of course due to the better manipulation of the charge by the operator. One of the essential conditions to be desired in charging a furnace is to maintain the charge level on top of the ore column. This may be obtained in two ways, one by distributing the material by hand-rabbling, and one by properly spotting or placing the charge when dumping.

ADVANTAGES OF HAND-CHARGING AND RABBLING

The operation of spreading the charge by hand-rabbling becomes increasingly difficult as the areal dimensions of the unit and size of the charges increase. This is apparent. If mechanical pushers are used on the top

of the charge, other mechanical difficulties arise. Also the desirability of performing hand operations on a furnace is of considerable advantage. Most of the charging may be done by a shovel and hand labor. In this way 20 lb. may be the maximum load thrown on the charge at one time and place. This load may be placed exactly where desired. The small unit charges may be well mixed beforehand. The charges do not fall from a great height onto the ore column, and do not develop a tendency for the charge to pack. Light loads of charge and low drop make a loose ore column and good smelting conditions. Stoking is another essential. The hand-operated furnace can be more successfully stoked to prevent crusts from forming and causing the charge to keep moving down and not be allowed to become dead in the furnace. The accumulation of dead charge in a furnace will at once cut down production and recoveries. As the metal bearing materials incipiently fuse and crust the furnace, loss of metal results, and all calculations are thrown out. Heavy wall crusts affect linings, by the more rapid deterioration of side walls. In all the above respects the hand-controlled furnace shows points of superiority in operation, recovery and production.

In furnaces having areas and volumes where hand labor for charging has to be eliminated, mechanical appliances must be used. The operation of some of these mechanical appliances has considerable to do with production and recoveries in the furnace. As the majority of such methods dump the charge from above and usually from 8 to 12 ft. heights and require rather large unit charges, a decidedly different set of conditions exists from that of charging small mixed charges by the shovel from a low fall. The large charge (500-1000 lb.) falls with considerable impact. The heavier material of the charge, falling with greater impact and settling first, upsets the proper feeding of the materials. This condition usually upsets the careful mixing which may previously have been accomplished. Also ore or limerock may fall around the electrode, when the opposite may be desired, and carbonaceous material falls next to the walls. By the carbon material falling next to the walls the temperature of the walls is considerably increased. This also results in areas in the center of the furnace being impoverished in reducing material. Also one part of the furnace may be running faster than another part and it may be necessary to place charge where most needed. This necessitates some rabbling and distribution of the material over the furnace top. With an 18 by 10-ft. furnace top area, this is inefficient at best. In rabbling, a workman usually draws or pushes more of the light material than heavy material, consequently uniformity throughout cannot be obtained. These conditions are prime effectives on production and recovery in an electric smelting furnace. These conditions also eliminate some of the smooth operations, such as occur on furnaces of lesser dimensions, volume and capacity. They will often account for otherwise unexplained factors.

COMPARISON OF METHODS OF CHARGING

It might be of interest to mention two methods of charging used on 20-ton alloy furnaces (20 tons of alloy per day). One method was by straight drop, and the other by a movable spout.

In the straight drop method, stacks were built between electrodes, and the charge dropped directly from above. The drop was about 11 ft. It was necessary to drop at least 500 lb. of mixed charge at one time. The

charge descended on the top of the ore column with heavy impact and packed the material densely around two adjacent electrodes, as the stacks were between. Then by rabbling usually the light charcoal was pushed or pulled away, and only ore and limerock were left around the electrodes. This condition, it was seen, soon upset furnace conditions and a change was necessary. The charges were then dropped, charcoal or coke first, and then ore and limerock. This rectified matters to a certain extent, but it required more labor on the feed floor, and caused considerable loss of charcoal, by dusting, and disintegration of lump charcoal when the ore fell upon it. The whole method of charging was then changed, having proved unsatisfactory.

A movable hopper over the furnace running on a track had an outlet into a long spout, which, being on a swinging joint, moved forward and backward. When a charge was dumped from the scale car into the hopper the spout was moved forward and backward, thus distributing the charge from front to back of the furnace. From the lip of the spout the charge fell about 3 ft. to the top of the ore column. As the deflection plate in the hopper was set at about a 45 degree angle, the velocity of the charge was checked from a straight-down fall, and as a result the charge fell with considerable less impact from the lip of the spout. In this way charcoal or coke could be fed separately, properly distributed, and ore following could be also be distributed. A minimum of rabbling was necessary and operations soon showed the merits of the change. The results were uniform smelting, absence of heavy crusts in the furnace, less labor necessary on the working floor, cooler top, better cooling of side walls, less dust in charging, less disintegration of charcoal.

The continual addition of 200 to 400-lb. charges is to be preferred to 700 to 1000-lb. charges dumped at long intervals of time. In this instance again, dimensional features and methods of meeting increased capacities control recoveries and production of metal. Also, the 16-ton furnace may be made equally efficient as and more efficient than the 5-ton furnace, by proper mechanical appliances.

While the method of charging a furnace is largely dependent on the quantity of charge required per unit of time, the capacity of the furnace usually decides the method to be used. With the dimensional features of the furnace already decided upon, the method of proper charging should be given careful consideration.

RELATIVE METAL RECOVERIES FROM DIFFERENT ORES

I also wish to refer here on the relative recoveries of metal from smelting carbonate ores, compared with smelting the oxide and silicate ores of manganese. Carbonate ores carrying not over 8 per cent silica should give lower losses from slag loss than silicate ores. As the manganese oxides are not chemically combined with silica to such large percentages in the carbonate ores, less slag losses would occur, the reason for this being freedom from rhodonite in the rhodochrosite ores.

In the silicate ores (rhodonite) the lime replaces some manganese oxide, forming lime silicates. But as lime replaces some manganous oxide, all replaced manganous oxide is not reduced by carbon to manganese. A large per cent of the manganous oxide passes again into solution with the silicates of lime and escapes reduction, forming double silicates of lime and manganese. Therefore on rhodonite ores and oxide ores carrying rhodonite, it is doubtful if slag content of manganous

oxide as low as 6 per cent and 8 per cent can be produced. The manganese dioxide, on which available oxygen is calculated, is also the base for available manganese. The following table gives analyses of some of the rhodonite ores smelted, the recoveries of alloy and analyses, with slag analyses, taken from operations on the 1800-kw. furnace referred to as the second furnace in this article:

ORE ANALYSES. RHODONITE AND OXIDE ORES

Mn	MnO	MnO ₂	SiO ₂	Fe ₂ O ₃
41.8	11.5	52.0	24.3	2.20
47.6	16.0	55.0	23.3	2.30
44.1	18.4	47.3	21.9	1.20
46.9	16.1	54.6	15.0	2.10
45.8	14.4	54.8	16.0	1.60
45.9	11.9	58.0	16.4	2.10

Manganese recoveries.....72 per cent to 80 per cent

ALLOY ANALYSES

Mn	Fe	Si	S	P	C
81.9	9.50	0.95	0.034	0.044	7.05
82.5	10.50	1.60	0.020	0.085	4.95
81.4	11.55	1.35	0.005	0.090	5.55
81.3	11.50	1.41	0.004	0.102	5.65
82.0	11.20	1.56	0.002	0.075	4.95
81.7	11.80	0.50	0.003	0.090	5.75

SLAG ANALYSES

MnO	CaO	SiO ₂
14.6	41.7	36.8
17.9	42.2	34.7
16.7	42.3	34.7
16.3	41.3	36.0
14.4	42.0	40.2
11.18	44.8	37.2
18.8	34.5	37.2
17.5	39.7	36.6
18.2	37.6	35.7

The manganous oxide content of slags in these operations may have been decreased by increased carbon content on the charge. But as charcoal and coke were the items of greatest expense, it was necessary to conserve these materials. Also running on heavy lime burdens caused carbide accretions and electrode losses by carbon going into solution. As the manganese carbides form a soft disintegrating alloy, it was desired not to go over 6.5 per cent carbon in the alloy.

PROPERLY DESIGNED LARGE FURNACES ARE EFFICIENT

From the foregoing accounts it might be inferred that "large" size furnaces are considered wasteful and inefficient. But the "large" furnace properly designed in each component part can be made equally as efficient as a unit one-half or one-fourth the volume or capacity. By increasing the power input to double or triple is not alone sufficient. Decreasing the area of crucible to electrode area may not bring desired conditions. By a careful study of the relations which essential components bear to each other, the efficient operating unit can be constructed regardless of size of transformers, output and volume, etc. On equally rich burdens and nature and size of reducing agent and ore charge, electrical conditions may be brought to a condition of greatest heat development in the furnace. As the nature of the material in the furnace and the magnitude of its heating paths are the principal factors in producing heat, to bring about the chemical reactions these factors must be properly considered and utilized, so that large units may be built with high efficiency of power input and metal recovery.

In any smelting apparatus the rate of applying the heat is the essential problem. The chemical combinations involved produce both axothermic and endothermic reactions. Gases issuing from the furnace carry away heat units in their sensible heat. Radiation accounts for another decrease of heat in the furnace. By tapping slag and alloy, heat is again drawn from the furnace.

In the electric furnace, heat is supplied by the electrical resistance of the charge, and by multiple arcs of contact, at the electrode ends. The furnace must be in proper condition to quickly build up at all times its load for heat generation. The furnace crucible should be so proportioned that after tapping, large volumes of cold charge do not come down and cut off the load for long periods, by cooling the crucible and its contents.

The greater the rate of power input to the furnace the more easily can the operations be controlled. Power input is heat input. Rate of heat input means rate of metal output. Kilowatt-hour consumption is directly balanced against calories and metal output. But only by proper design can power input be properly and efficiently utilized for alloy or metal production and recoveries.

Milwaukee, Wis.

An Apparatus for Determining the Thermal Conductivity of Metals

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THE precise determination of the thermal conductivity of metals by a simple laboratory testing device is becoming of more and more importance in numerous technical and scientific lines. The enormous development of the gas engine in the last few years has brought forward the problem of cooling the cylinder and piston, and the thermal conductivity of the metals composing these parts plays an important part in the efficiency of any cooling system. All of the various types of heat interchangers are dependent primarily on the high thermal conductivity of their walls, which are usually composed of some sort of metal. The conductivity of the pure metals has been known with some precision for a long time, but that of the alloys is still unknown except in a few instances, and the thermal conductivity of an alloy cannot as yet be predicted from its constituents.

At the suggestion of Prof. Zay Jeffries, director of research, Aluminum Castings Co., the author designed and built the apparatus which is here described, for determining the coefficient of thermal conductivity of metals, especially aluminum alloys.

The apparatus was designed for use in a commercial laboratory and consequently was made as simple as possible, consistent with the results desired. It was required that the specimens be of such shape that they could be easily cast and prepared for testing with a minimum amount of machine work. The temperature range to be covered by the tests was from 20 to 600 deg. C., and the precision required was 2 per cent.

The familiar guard-ring method used so much for determining the thermal conductivity of heat insulators was used as the basis of the design, modified, of course, to meet the conditions of the problem. The tester consisted, essentially, (1) of a heater, (2) a guard-ring, not necessarily of the same material as the specimen, (3) two continuous flow calorimeters, and (4) three thermocouples used in measuring the temperature of different parts of the specimen.

Referring to the sketch of the apparatus, we have the heater A, consisting of a coil of suitable resistance wire wound on a brass core, and insulated from it by thin sheets of mica. A suitable rheostat is connected

in series with this heater, in order that the temperature may be regulated at will, and an ammeter placed in the line is a great convenience, but not a necessity. This core is screwed into a hollow brass cylinder *B*, as shown in the sketch.

The specimen *C* is a rod, approximately 14 in. long and $\frac{1}{4}$ in. in diameter, the lower end of which is threaded into the brass cylinder *B* with a standard $\frac{1}{4}$ -in. thread, while the last 2 in. of the upper end is turned down to $\frac{1}{8}$ in. in diameter and cut with a fine thread, approximately 24 threads to the inch. The latter end has also a slot cut across the top, so that a screwdriver may be used for removing the specimen at the end of a test. The calorimeter *D*, which is screwed on this end of the specimen, is formed out of a solid cylinder of brass, drilled and tapped $\frac{1}{8}$ in. diameter, 24 threads to the inch, on top of which a $\frac{1}{16}$ -in. square thread is cut, forming the water passage around the specimen. The two ends of this square thread are connected to the two thermometer wells *E*, in which are inserted thermometers used in measuring the temperature of the inlet and outlet water.

The guard-ring *F* consists of a brass tube, 2 $\frac{1}{2}$ -in. outside diameter and $\frac{1}{4}$ -in. wall, which is screwed onto the brass cylinder *B*. The other end of the guard-ring has a square thread cut on the outside for a length of 2 in., over which a thin brass sheet is soldered, forming the guard-ring calorimeter. One end of this square thread is connected directly to the inlet water supply, while the other end first passes through a thermometer well, and thence to the waste pipe.

The temperature of the specimen is measured at three points along the rod, by means of small thermocouples inserted through holes drilled in the guard-ring and the specimen. The holes in the specimen should not have a diameter in excess of $\frac{1}{16}$ in., and are spaced 4 in. apart in such a manner that the center hole is equidistant from the calorimeter and the cylinder *B*. The space between the specimen and the guard-ring is filled with a thermal insulator (Fire-felt), in order to prevent convection currents from carrying heat to the calorimeters directly; in like manner the two calorimeters are insulated from each other, so as to eliminate any chance of transfer of heat between them. The entire apparatus is insulated on the outside with about 2 in. of good insulation to prevent any unnecessary heat loss and to secure constant temperature conditions.

The temperatures of the specimen and the guard-ring must be essentially the same where they leave the brass block *B*, both being screwed to the block and in intimate thermal contact with it; also the temperatures at the point where they enter their respective calorimeters must be the same, both being in contact with water at approximately the same temperature. If the specimen and the guard-ring are at the same temperature at their ends, and there is no appreciable heat flow outward in comparison with the flow of heat along the metal, any two points on the specimen and guard-ring, at the same distance from the heater, will be at

approximately the same temperature, and consequently there will be no transfer of heat between the specimen and guard-ring. In order to check this statement experimentally, thermocouples were placed on the guard-ring at points corresponding to the thermocouples in the specimen, and the temperatures at any two corresponding points were found to be the same.

If an electric current is allowed to flow through the heating wires, the temperature of the block *B* will be raised, and if a constant stream of water is maintained through the calorimeters, a uniform low temperature will be obtained at the upper end of the specimen and the guard-ring. The temperature of the block *B* will eventually become constant, provided the heating current is kept constant, and we shall have a uniform flow of heat along the specimen and the guard-ring toward the calorimeters. Any quantity of heat that enters the specimen from the block *B* will flow along the specimen without any gain or loss of heat until it reaches the calorimeter, because there is no tendency for heat to flow unless there is a difference in temperature. All of the heat that enters the calorimeter *E* flows from the specimen, because the calorimeter is very nearly at the same temperature as the surrounding air and the guard-ring calorimeter, and in addition is insulated from these.

When thermal equilibrium has been established, which takes about 2 hr., the coefficient of thermal conductivity may be calculated if the following data are known:

- A* = Cross-sectional area of the specimen in sq. cm.
- D* = Distance between any two thermocouples in cm.
- T₁* = Temperature of the hotter thermocouple in deg. C.
- T₂* = Temperature of the colder thermocouple in deg. C.
- T₃* = Temperature of the inlet water to "D" in deg. C.
- T₄* = Temperature of the outlet water from "D" in deg. C.
- W* = Weight of water in grams, passing through the calorimeter during one second.

The coefficient of thermal conductivity, *K*, expressed in gram calories per second, per sq. cm., per cm. thickness, per 1 deg. C. temperature difference, may be calculated by the following expression:

$$K = \frac{W (T_4 - T_3) D}{(T_1 - T_2) A}$$

The data taken from a sample of commercially pure aluminum rod may be of help in showing how the values run for an actual observation.

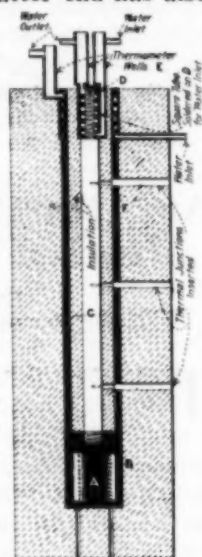
<i>T₁</i> = 485 deg. C.	<i>A</i> = 2.86 sq. cm.
<i>T₂</i> = 120 deg. C.	<i>D</i> = 20.3 cm.
<i>T₃</i> = 16.13 deg. C.	<i>W</i> = 3.11 g. of water per second.
<i>T₄</i> = 23.40 deg. C.	

$$K = \frac{3.11 (23.40 - 16.13) 20.3}{(485 - 120) 2.86} = 0.440$$

In order to express *K* in B.t.u. per 24 hr., per sq. ft., per in. thickness, per 1 deg. F. temperature difference, the above value must be multiplied by 69,800.

In regard to the precision of the results, it will be seen readily that any of the factors used in the equation can be determined with much more than the required precision, consequently only the constant errors due to the design of the apparatus will affect the result so as to make the value of *K* in error more than 2 per cent.

The question of direct conduction to the calorimeter *D* by the insulation between the specimen and the guard-ring is negligible because the relative conductivity of the insulation and the specimen is about 1 to 2000, and their respective areas are approximately 7 to 1. The total amount of heat conducted by the insulation is only 7/2000 of the heat conducted by the specimen, and of course no large part of this heat would go into the calorimeter *D*. The question of a transfer of



SKETCH OF THE APPARATUS

heat between the specimen and the guard-ring depends upon the nature of the specimen and the guard-ring. If they are both of the same material, there will be no transfer of heat, because there will be no difference of temperature between the adjacent parts of the two. If they are not of the same material, their similarity of temperature and the transfer of heat between them will depend on possible differences in the temperature coefficients of their thermal conductivity, i.e., their change of thermal conductivity with temperature change, and is independent of their relative conductivities. Even at the worst, this loss is certainly small. The average area of the insulation, transmitting heat between the specimen and the guard-ring, is approximately 110 sq.cm., and assuming the relative conductivities stated above, the loss of heat to the guard-ring, with the specimen averaging 20 deg. C. higher temperature, will be only 1 per cent of the heat transmitted by the specimen. The temperature coefficients would necessarily have to be very different to produce an average temperature difference of 20 deg. C.

On account of the small temperature difference between the two calorimeters, which are also insulated from each other, there will be a negligible transfer of heat between them. If the thermometer wells are designed like those in the sketch, it has been clearly shown by a large number of tests that the thermometers will truly record the temperature difference between the entering and exit water and there will be no chance of any error from this source greater than $\frac{1}{2}$ or 1 per cent. I believe that all of the larger sources of error have been taken into account and that they cannot affect the result by amounts as large as 2 per cent.

In conclusion, it might be of interest to state that an apparatus of this sort has been in use for over six months in a commercial laboratory and has given satisfactory service. I also wish to express my thanks to Prof. C. L. Norton of the Massachusetts Institute of Technology for his help in the design and construction of this apparatus.

Rogers Laboratory of Physics,
Mass. Institute of Technology,
Cambridge, Mass.

Mine Output of the Central States, 1918

The 1918 production of non-ferrous metals from the mines of the Central States was 73,643,398 short tons less than for 1917, in value \$30,861,000. The decrease, principally due to the curtailment of production of the Michigan copper mines, was for copper 28,703,337 lb. and for silver 192,746 oz.

The output of Missouri zinc decreased 76,926 short tons, while the Oklahoma production increased 75,566, the two States changing places as the largest producer.

Producer Gas Costs

The following table of producer gas costs published by the Steere Engineering Co., Detroit, includes fuel, power, repairs and maintenance, labor and supervision, interest and depreciation; in fact, every item of cost except the interest and taxes on the land occupied.

Cost of One Ton of Coal at Plant	Producer Gas Costs per 1000 Cu.Ft. for Coal Costs Given		Costs at Which Other Fuels Must Be Bought to Obtain the Same Number of B.t.u. as When Buying Producer Gas		With Coal at the Price Given		Coal Gas or Carburetted Water Gas per 1000 Cu.Ft.		Blue Gas per 1000 Cu.Ft.	
	Hot Raw Producer Gas at Offtake	Clean Cold Producer Gas	Natural Gas per 1000 Cu.Ft.	Fuel Oil per Gallon	Coal Gas per 1000 Cu.Ft.	Coal Gas per 1000 Cu.Ft.	Coal Gas per 1000 Cu.Ft.	Coal Gas per 1000 Cu.Ft.	Blue Gas per 1000 Cu.Ft.	Blue Gas per 1000 Cu.Ft.
22.00	3.13c.	4.15c.	23.7c.	31.5c.	2.91c.	3.86c.	12.6c.	16.72c.	6.45c.	8.59c.
2.50	3.55	4.57	26.9	34.67	3.3	4.25	14.3	18.40	7.34	9.45
3.00	3.96	4.98	30.1	37.84	3.69	4.64	16.6	20.09	8.20	10.32
3.50	4.38	5.40	33.3	41.01	4.08	5.03	17.65	21.77	9.07	11.18
4.00	4.79	5.82	36.3	44.18	4.46	5.42	19.3	23.45	9.92	12.05
4.50	5.21	6.24	39.5	47.35	4.85	5.81	21.0	25.13	10.78	12.91
5.00	5.63	6.66	42.7	50.52	5.24	6.20	22.7	26.82	11.65	13.78
5.50	6.05	7.08	45.9	53.69	5.63	6.59	24.35	28.50	12.5	14.64
6.00	6.46	7.49	49.1	56.85	6.01	6.97	26.0	30.18	13.36	15.50

HEATING VALUES USED

Producer gas.....	145 B.t.u. per cu.ft.
Natural gas.....	1,100 B.t.u. per cu.ft.
Fuel oil.....	135,000 B.t.u. per gallon
Coal gas or carburetted water gas.....	585 B.t.u. per cu.ft.
Blue gas.....	300 B.t.u. per cu.ft.

These costs are based on the plant operating with a 100 per cent load factor, that is, operating at rated capacity 24 hours per day, 365 days per year. Comparatively few plants have a 100 per cent load factor, and therefore it is necessary to take this very important point into consideration when estimating the cost of gas.

The cost of producer gas, with a reasonable degree of accuracy, may be estimated for any load factor by applying the formula:

$$C = T + \left[\left(\frac{R \times 400}{A \times B} \right) - 2.38 \right]$$

Where

C = Cost of producer gas per thousand cu.ft. under conditions specified

A = Number of feet of gas used per day

B = Days per week plant is in operation

T = Cost figures shown in table at 100 per cent load factor

R = Rated hourly capacity of plant in cubic feet

It also must be kept in mind that furnace efficiencies have a very great bearing on the cost of the finished product. Without regeneration or recuperation producer gas cannot be used as efficiently as the more concentrated fuels. The expense of the distribution system and the furnaces also have an important bearing on the total cost of doing the work.

MINE OUTPUT OF THE CENTRAL STATES, 1918 (a)
(1917 Output Shown for Comparison)

State	Ore Treated (Short Tons)		Silver (Fine Oz.)		Copper (Lb.)		Lead (Short Tons)		Zinc (Short Tons)		Total Value	
	1917	1918	1917	1918	1917	1918	1917	1918	1917	1918	1917	1918
Arkansas.....	203,600	37,000					382	120	6,691	951	\$1,430,668	\$110,122
Illinois.....	237,340	280,900	7,186	8,171			1,439	2,273	4,267	3,792	1,123,897	1,021,081
Kansas.....	903,400	1,025,400					3,025	7,252	20,249	30,197	4,651,096	6,525,638
Kentucky.....							123	185	751	315	174,360	83,600
Michigan.....	12,400,723	11,321,365	688,551	509,467	255,710,128	226,794,139	234,156	194,175	132,918	55,992	70,376,231	56,527,619
Missouri.....	17,024,800	9,146,800	61,586	46,939	365,013	577,665	26,358	56,097	85,835	161,401	67,540,500	37,953,016
Oklahoma.....	3,523,200	5,754,700					4,139	4,533	59,742	50,014	22,043,916	37,340,756
Wisconsin.....	3,014,800	2,377,300									12,899,276	9,746,234
Total.....	37,307,863	29,943,465	757,323	564,577	256,075,141	227,371,804	269,622	264,635	310,453	302,662	\$180,239,944	\$149,388,066

(a) The average market prices used by the U. S. Geological Survey in figuring values of production of metals for the calendar year 1918 are: Silver (average price as given by Bureau of the Mint), \$1 per fine oz.; copper (sales price all marketable grades), \$0.247 per lb.; lead (sales price all grades), \$0.071 per lb.; zinc (spot price, all grades), \$0.091 per lb.

(b) Includes only ore from Northern Illinois.

(c) Tonnage not available.

The Flash and Burning Points of Gasoline-Kerosene Mixtures*

Effect of Gasoline Content on the Flash and Burning Points of Kerosene — Foster Closed Cup and Cleveland Type Open Cup Methods Compared — Flash and Burning Points of Kerosene Mixed With "Low-Test" Gasoline, "High-Test" Gasoline and "Petroleum Ether"

By JAMES T. ROBSON AND JAMES R. WITHROW

THE results indicated by the investigations covered in this paper and by the literature on the subject which is reviewed herein are:

The profound effect upon the flash and burning point of kerosene and therefore the fire and explosion hazard of the smallest percentages of gasoline or similar volatile petroleum fractions added to the kerosene.

Gasoline cannot safely be permitted in kerosene.

The early records of the influence of light petroleum distillates upon burning oils were based upon fractions radically different in properties from similarly named products of modern refining.

The main original need for State flash point laws has ceased. Nevertheless, public safety still requires their enforcement.

The Foster closed cup flash determination permits the presence of much lighter petroleum distillates than the Cleveland open cup method.

The gasoline and other light petroleum fractions are found to be miscible instantaneously with kerosene if intimately mixed. It is concluded that stratification in large tanks is merely due to insufficient mixing or lack of time for diffusion.

While ordinary kerosene of commerce extinguishes a burning match, the addition of gasoline to the extent of 1 per cent may give a flash; 3 to 5 per cent gives violent flashing, and 7½ per cent inflames at once. Any of these would have given explosions if confined.

The relation is established between flash and burning point and percentage of volatile petroleum fractions admixed with kerosene. Working conditions are given minutely, to establish the comparative dependability of the final values for future cases of comparison. Distillation and gravity characteristics of the fractions used are recorded.

Because of our inability to obtain material assistance from the literature on the influence of the addition of gasoline to kerosene with respect to the explosion hazard after the kerosene was marketed, it seemed desirable to publish portions of the work made necessary by this scanty literature.

FATAL RESULTS FROM GASOLINE-CONTAMINATED KEROSENE

One or several deaths appear to have resulted from explosions in the use of kerosene admitted to have been marketed in Ohio by an oil refiner. It is also admitted that an employee of the refiner inadvertently pumped gasoline into a kerosene storage tank and also that kerosene was subsequently sold from this tank batch. It was claimed by the plaintiffs that the kerosene causing fatal explosions could be directly traced to this contaminated kerosene storage. It is claimed by employees of the refiner that a gallon sample was drawn off of the contaminated kerosene tank and its flashing properties tested and found "safe."

It would probably have to be admitted that a draw-off of one gallon would not clear the uncontaminated kerosene from the draw-off line, and as a result the

"safe" flash test would not reveal the true character of the tank contents. In this same connection also it was claimed by the plaintiff that stratification probably existed in the tank anyway and therefore a sample withdrawn from the bottom of the tank would inevitably test "safe" in flash point. It was also claimed that dispensing from said tank would soon reach a highly dangerous zone because richer in gasoline.

No exact evidence was available as to the amount of kerosene originally in the tank or the amount of gasoline pumped into it or the amount of the mixture resulting. It would probably have to be admitted, however, that there was more than 2 per cent gasoline as a minimum admixed with the kerosene or any lot sold therefrom if admixture were complete. No actual sample of the mixture appears to have been preserved by either side. The samples causing the explosions were destroyed thereby.

In 1861 Allen (*Smithsonian Reports*, 1861, p. 330) reported on the "Explosibility of Coal Oil," an investigation instigated by the Rhode Island Mutual Fire Insurance Co. to study various "coal oils." Both petroleum and coal-tar products were included under "coal oil." That gasoline was then a drug on the market was pointed out, as was the artificial production of kerosene with a kerosene gravity by judicious mixtures of higher and lower fractions than the kerosene fraction proper.

Allen made flash point determinations in open cups floating in water at various temperatures. This seems to us a cumbersome manipulation as compared with our simple direct heated or water-bath heated devices. He did not know the amount of "adulteration," however.

K. V. Weise in Wagner's "Chemische Technologie," 1871, p. 865, with the open cup method found:

	Sp.Gr.	Flash Point, Deg.	Burning Point, Deg.
Petroleum.....	0.805	30	43
Petroleum + 1 per cent naphtha.....	0.710	25	40
Petroleum + 1 per cent naphtha.....	0.710	22	32
Petroleum + 3 per cent naphtha.....	0.710	20	29

This work is by far the most complete along this line in the literature. The oils used, however, are quite different from those with which we are concerned. The closest to our conditions are these:

	Flash Point, Deg.	Burning Point, Deg.
Petroleum, 0.806.....	55	70
Petroleum + 2 per cent naphtha.....	45	60
Petroleum + 4 per cent naphtha.....	24	55
Petroleum + 10 per cent naphtha.....	20	32

There was no closed cup work. The author states that for the determination of the naphtha content, neither the flash point method nor fractional distillation is satisfactory.

In 1887 Crew ("Treatise on Petroleum," 1887, Philadelphia, Henry C. Baird & Co., p. 395) pointed out

*Read at the meeting of the American Institute of Chemical Engineers, Cambridge, Mass., June 20, 1919.

adulteration of kerosene with dangerous low-boiling fractions and presented a simple "saucer" test to show whether or not a given oil was dangerous for use in lamps.

Crew quotes experiments of Dr. C. B. White of New Orleans resulting as follows:

	Flash Point, Deg. F.	Burning Point, Deg. F.
Oil alone.....	118	135
Oil with 1 per cent benzene—65 deg. B.....	112	129
Oil with 3 per cent benzene—65 deg. B.....	103	123
Oil with 5 per cent benzene—65 deg. B.....	96	116
Oil with 10 per cent benzene—65 deg. B.....	83	102
Oil with 1 per cent benzene—72 deg. B.....	107	133
Oil with 5 per cent benzene—72 deg. B.....	70	105

Allen's "Commercial Organic Analysis," 4th ed., Blakiston, Philadelphia, 1914, p. 120, states that Dr.

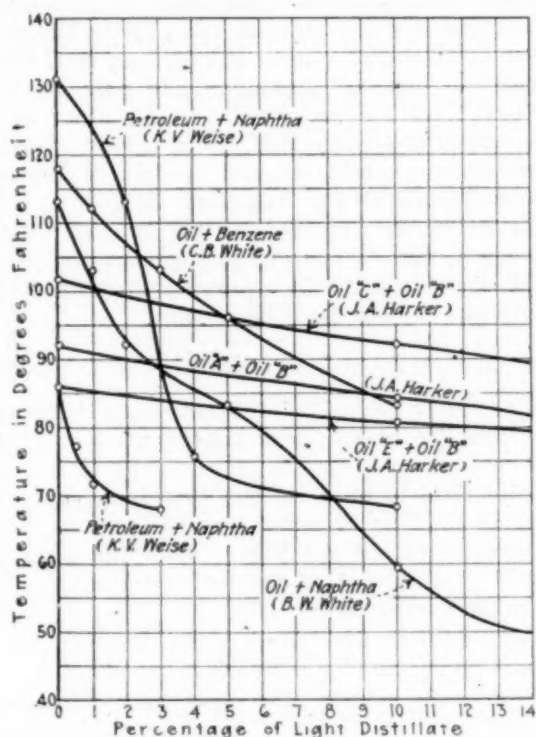


FIG. 1. OPEN CUP FLASH POINTS—EARLY WORKERS

B. W. White, using the "open test," with oil which originally flashes at 113 deg. F. found that

1 per cent naphtha reduced flash point to	103 deg. F.
2 per cent naphtha reduced flash point to	92 deg. F.
5 per cent naphtha reduced flash point to	83 deg. F.
10 per cent naphtha reduced flash point to	59 deg. F.
20 per cent naphtha reduced flash point to	40 deg. F.

No further information is given. It is not evident whether this is the same Dr. White referred to by Crew.

These results correspond only approximately with ours. They are upon the older type of low-flash kerosene and with uncertain procedure. They are interesting, however, as tending to show the influence of definite admixture of an oil of known flash point. No modern case has been found by us where there is a clear correlation between definite admixture of characterized products and the flash and burning tests with prescription of conditions of test.

Steingraber (*Oesterr. Chem. Zeit.*, 1900, pp. 589-99; *J. Soc. Chem. Ind.*, 1901, p. 352) tried to determine how far the properties of "illuminating" fractions of oil were affected by benzene mixtures. He used 21 deg. C. flash oil as standard and added various amounts of benzene and higher fractions. His results showed that only benzenes boiling below 100 deg. C. have strong influence on flash. Additions of higher boiling benzenes

have little effect; 21 deg. C. (or 70 deg. F.) is too low as a flash oil to be taken as a standard to determine effect of benzene on flash. With 110 to 120 deg. F. flash oils as standards, effect of higher boiling benzenes are somewhat different than found by Steingraber.

H. C. Sherman, T. T. Gray and H. A. Hammerschlag (*J. Ind. Eng. Chem.*, vol. 1, 1909, p. 13) compared the calculated and determined viscosities and flashing and burning points of oil mixtures. This work shows that the calculated flash point is not the same as the actual. The work was not on kerosene, however.

J. A. Harker and W. F. Higgins in "The Methods and Apparatus Used in Petroleum Testing" (*Nat. Phys. Lab., Collected Researches*, vol. 8, 1912, p. 38) give a method for calculating flash points of different mixtures of oils. No method is given of identifying their oils.

Intervals (10 per cent) of mixture used are so large that it is not justifiable to determine flash point for any intervening mixture, say 92 or 97 per cent.

Harker's work intends to give a method of determining the flash point when the composition is known but omits identification of his oil.

Our work will give approximately the composition of the mixture from a determination of the flash point

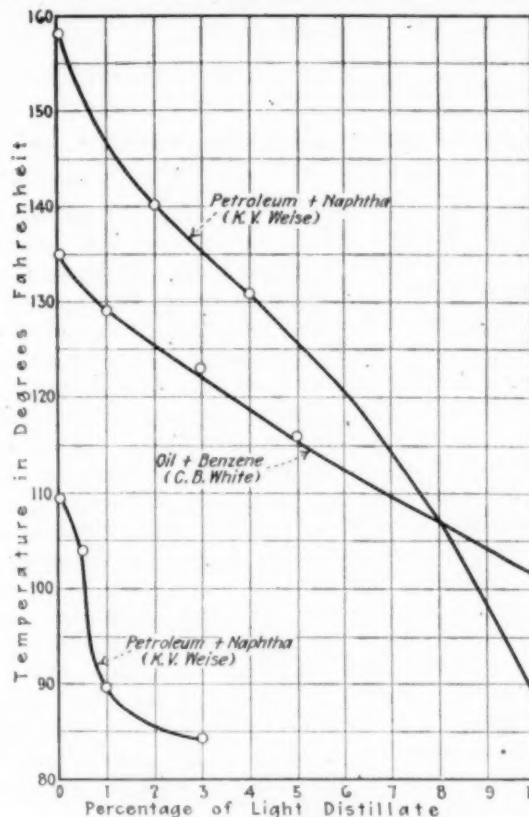


FIG. 2. BURNING POINTS—EARLY WORKERS

and interpreting on the basis of the distillation curves which identify our oils.

Curves representing the values recorded by these earlier workers appear in Figs. 1 and 2.

FACTORS INFLUENCING FIRE HAZARDS OF GASOLINE AND KEROSENE

Strictly speaking, the flash point by itself does not determine the fire hazard of any substance. The factors which also influence fire hazard are:

- Volatility.
- Boiling point.
- Vapor pressure.
- Vapor density.

- (e) Diffusibility and tendency of vapors to travel.
- (f) Explosive limits in air.
- (g) Tendency to chemical change.
- (h) Quantity of heat liberated per unit of volume.
- (i) Temperature of flame.
- (j) Corrosive action.
- (k) Behavior toward water before and after ignition.
- (l) Tendency of substance to leak.
- (m) Prolonged heating effect.

Kerosene in a tropical climate gives lower "flash" than the same oil in a temperate climate. The trouble is due primarily to accumulation of vapors caused by continued high temperature and secondarily in discharging or moving oil by vapors disengaged on pouring and shaking.

It is well known that cold kerosene of good legal quality will not take fire when light is applied, nor will the supernatant vapor inflame. The "burning test," fire test, i.e., temperature at which oil permanently inflames, is sometimes taken as a test of burning or firing value, but is not strictly reliable since oils spilled in a thin flow will ignite instantly on approach of a flame, even when the burning point is considerably higher than the flash point. It is also well known that with refined burning oil no inflammable or explosive mixture could be formed, even in the absence of ventilation, up to 70 deg. F. At temperatures much above 80 deg. F. and with no ventilation, such an atmosphere could be produced with most oil.

EARLY FLASH POINT LAWS AND PRESENT REVERSED STATUS OF GASOLINE AND KEROSENE PRODUCTION

It would have to be admitted that the presence of lighter or gasoline fractions in kerosene has long ceased to be profitable to the refiner. Hence as an evil it has needed little attention in recent times.

If commercial gasoline of any gravity is accidentally pumped into or by faulty valving or otherwise gets into a kerosene fraction storage, its detection is quite simple by the flash test. Simple considerations indicate, however, that this can be no quantitative indication of the amount of such contamination except the "flash point" determination be calibrated with reference to this particular kind of occurrence. Individual oil companies or chemists doubtless have felt the need for such a correlation and perhaps have made it. Few of these results have gotten into the literature. From year to year we have had cases arise which raised the question: "How much gasoline does this particular contamination represent?" Recently the question arose again under the circumstances already mentioned, which made a partial answer to the general question necessary, and the results obtained with our set of conditions are here recorded.

In the earlier period of petroleum refining, kerosene or "burning oil" was the valuable light product or early distillate. At that time it was a temptation to producers to put into kerosene all the traffic would stand of lower boiling (gasoline) fractions, together with the maximum of higher boiling fractions next above the burning oil, to balance the lighter gravity of the gasoline fraction. This virtually amounted to a physical synthesis of kerosene by mixing with each other the next lower and higher fractions. This was a perfectly justifiable procedure, if a safe one, to meet commercial demands in the days that developed "cracking" for burning oil formation. "Gravity," however, was not the sole consideration. There was a safety limit which was important because the consumers in the homes of

the land might be made the victims of unnecessary fire hazard, through refiners' carelessness or unscrupulousness in this connection. Many tragedies resulted and legislation put a curb to syntheses of this kind by setting legal limits in a modified practical safety test in the flash point laws.

Of the law requirements (Gill's "Oil Analysis," 3rd ed., J. B. Lippincott, Philadelphia, p. 131; Stillman's "Engineering Chemistry," Chemical Publishing Co., Easton, Pa., 1916, p. 450) in 31 States, 19 fix a minimum flash point of 100 to 125 deg. F. and 12 States make a minimum "burning point" instead of flash point requirement. The burning point runs from 100 to 150 deg. F. in the States making the requirements. Four States set both a minimum flash and burning test and 16 no burning point test at all. These State laws specified in all except 8 cases the form of test, whether in "open" or "closed" apparatus. In only four cases was "open" testing permitted. In all other cases a closed tester was prescribed, thus closely simulating lamp or confined conditions, and the specific instrument was named such as the Tagliabue or Foster. From the results herein reported it will be seen that the closed cup of the Foster type may permit the presence of much more gasoline in a burning oil than does the open cup test for the same flash point.

GASOLINE AT THAT TIME A DRUG ON THE MARKET

In that early period of the petroleum refining industry, gasoline was a drug on the market. All the art of sales was directed to the creation of an outlet. The public had to be protected, therefore, against unscrupulous addition of gasoline to kerosene to increase production volume of the latter. Now the situation is reversed. The advent of the hydrocarbon or internal combustion engine about 1898 has created ever increasing demands for the gasoline fraction, so that the kerosene demand by comparison stands still. Now, as a result, the refiner puts everything into gasoline that the traffic will stand. This is as it should be, if understood. Consequently, the cheaper kerosene fraction is stripped as lean as possible of volatiles to raise the volume of the gasoline fraction. This puts so much of the front end of kerosene into gasoline that, of course, the gasoline is made heavier in gravity as is the kerosene. This greatly raises the flash and burning point of the kerosene, because the more volatile portion was cut off to add to gasoline. This is so effectively done in wide awake refineries that the State flash point laws are almost a dead letter. They, nevertheless, are necessary, because there are still a few poorly equipped or carelessly operated refineries. Occasionally errors or accidental contamination of kerosene storage will occur and the plant manager refuses to re-strip the mixture to save expense and instead works it off on the trade. We seem to meet occasionally just this situation in Ohio State oil inspection, and the protection to the public in these cases justifies the continuance of this State activity. In addition, there are the mistakes of delivery and petty storage-filling between wholesaler, retailer and eventual delivery to consumer. These, while not common, are much more common than refiners' mistakes, but are depressed in number by vigorous legal inspection and law enforcement, particularly in rural sections.

When the State Oil Inspector's office picks up offenders under the Ohio law it at times can trace a somewhat

connected series of infractions indicating a bad lot of kerosene and at times traceable to the refinery. In referring such matters to this laboratory the question is sometimes asked about the extent of gasoline contamination. It is not necessary to cite cases except to state that confirmation of the field inspector's test have at times been so good as to have the product pop off on lighting the paper in the Foster closed cup (the legal test instrument in Ohio). The taper is lighted customarily at 90 deg. F. and the Ohio minimum flash point for kerosene is 120 deg. F. Such a product is highly dangerous as a kerosene.

For this portion of the public welfare and safety, the State oil inspection laws are still an important factor. Careful, honest dealers and refiners have no quarrel with these laws.

THE FLASH AND BURNING POINT TESTS

There are some factors which must be clearly understood when dealing with flash point determination. The substances kerosene and gasoline themselves are not chemical compounds, but mixtures of hydrocarbons. "Kerosene" is a trade name. It is also called "coal oil" and "illuminating oil." Industrially it is understood to be a mixture of hydrocarbons "entirely" free from gasoline and naphtha on the one hand and from heavy hydrocarbons belonging to gas oil and lubricating oil on the other. This (kerosene) mixture is supposed to be only moderately soluble in alcohol but miscible in all proportions with ether, chloroform, benzene, petroleum spirit, volatile and fixed oils except castor oil.

Gasoline is a mixture of the lower series of hydrocarbons. It is lower in boiling point and lighter in gravity than kerosene. It includes all of them that are not "wild" or which will stay in a reasonably corked container and running as heavy in gravity as motor vehicles can start and navigate under. It usually includes all the old materials called variously petroleum spirit, petrol, benzene, etc. Formerly, that which distilled below 150 deg. C. was "spirit" or gasoline; 150 to 270 deg. C. was kerosene, and 270 deg. C. up was heavy oils. This was only conventional. Refineries ran largely on gravity. The consumer became acquainted with a specific gravity test. It was easy to perform and the refiner cut his fractions at various gravities in order to have his cuts average some other gravity required in the trade.

The flash point is the lowest temperature to which the oil need be heated under a fixed set of conditions to give off vapors in sufficient quantity when mixed with air to explode upon the approach of a flame.

The burning point or "fire test" is the lowest temperature at which oil will give off sufficient vapors to burn continuously when ignited.

The flash point and burning point tests are arbitrary. They are not measures of rigorous constants, yet they are capable of much refinement. They are accurate determinations of the practical effects of complex factors. For these reasons the values as determined are susceptible to influence from many sources, among which may be mentioned:

1. Barometric pressure.
2. Nature of bath as a source of heat.
3. Design of oil cup.
4. Features of thermometer.
5. Rate of heating.
6. Effect of prolonged heating or cooling.

7. Manipulation of test (manner flame is applied for flashing, etc.)

8. Room temperature and conditions.

9. Initial temperature of oil being tested.

10. Influence of water presence.

11. Personality of operator.

Even the determination of the flash point of a pure hydrocarbon (from the mixture whose vapor pressure effect is really the matter at issue) would be influenced by most of these factors.

The aim was a practical test, and experience has forced precautions and developed refinements. Burrell and Boyd (U. S. Bureau of Mines Tech. Paper 117) have pointed out the relation between vapor pressure and explosiveness of air gasoline mixtures as related to sewer atmosphere. No one appears to have correlated vapor pressures and explosion and ignition studies of vapor-air mixtures in connection with flash point determinations. The machines in use are accurate enough for short-cut results and are certainly practical in that they simulate burning lamp conditions.

CHARACTER OF THE MISCIBILITY OF GASOLINE-KEROSENE FRACTIONS

Among the questions raised in connection with the litigation referred to were (1) the nature or degree of miscibility of gasoline and kerosene fractions in each other, and (2) the influence upon the flashing properties of a kerosene in the event of miscibility proceeding at a practically instantaneous rate.

It is well known that petroleum fractions are miscible in one another. It cannot, therefore, be assumed that this has no limit in the case of any two restricted fractions in the absence of whole series of hydrocarbons of the original petroleum. Experiment upon various "gasolines" and a sample of kerosene, using every precaution to prevent mechanical mixing, practically always resulted, in the laboratory, in a product with the same flash and burning point as a thoroughly mixed sample. This appeared to be independent of the time of contact, position of admission to the kerosene, depth of kerosene layer (up to 1 ft.), portion of layer from which test sample was withdrawn, and the relative proportions used. This completely answers the ultimate degree of miscibility of the gasoline and kerosene fractions available for our experiments. The results also appear to answer the question of the nature of miscibility, i.e., it appears to be instantaneous. As these were laboratory experiments, they cannot be offered as conclusive, for they are subject to the criticism that an apparently instantaneous time factor in the laboratory may be quite a different matter in the plant where great volumes and depths of tank are factors modifying the situation. Also it is well known to refiners of light-boiling oils such as petroleum and coal-tar hydrocarbons that mixing or blending in tanks even as small as 10 x 12 ft. does not proceed automatically upon mere addition, but air agitation is necessary to insure completeness of mixing. We possess no exact knowledge on this subject and carried out no experiments in view of the trouble and expense attached thereto and because of the existence of definite experience that miscibility has a real time factor in large-scale operations. As an illustration, petroleum distillate tanks have been known to test 45 deg. B. at the bottom, 47 deg. at the middle and 49 deg. at the top. Again, pumping a light gravity oil into a 250-bbl. tank containing heavier oil, inlet at bottom, showed, when

240 bbl. were in the tank, 58 deg. B. at the bottom, 61 deg. at the middle and 68 deg. at the top; quantities used not known.

THE INFLAMMABILITY OF GASOLINE-KEROSENE MIXTURES

The following results indicate the effect upon the flash and burning behavior of kerosene used by admixtures of gasoline at ordinary temperature. These experiments were carried out in an ordinary granite ware cup, using 100 cc. of oil each time. In these experiments, "low-test" gasoline was used. The kerosene was measured in a 100 cc. graduate and the gasoline up through 3 per cent was measured in pipettes. From 5 per cent on, the gasoline was measured in the cylinder. With 100 per cent kerosene a lighted match when applied quickly or very slowly was extinguished. With 99 per cent kerosene and 1 per cent gasoline the match flashed when added but was extinguished when immersed in oil. With 3 per cent gasoline and 97 per cent kerosene, there was a flash more noticeable than with the 2 per cent mixture, but the match was also extinguished when immersed in the oil. With 5 per cent gasoline and 95 per cent kerosene the oil flashed violently, but did not burn. With $7\frac{1}{2}$ per cent gaso-

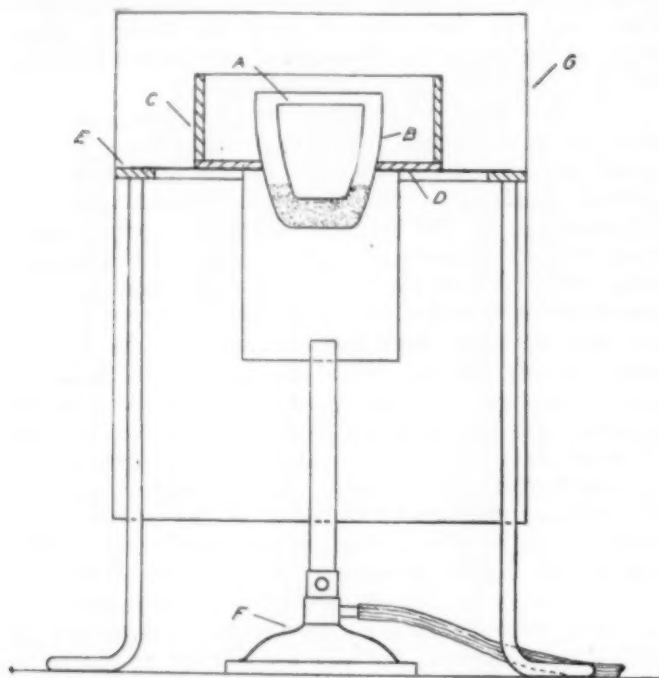


FIG. 3. OPEN CUP OIL TESTER

line and $92\frac{1}{2}$ per cent kerosene the oil flashed with a puff and readily burned when the lighted match touched it. With $12\frac{1}{2}$ per cent gasoline and $87\frac{1}{2}$ per cent kerosene the oil flashed with a loud puff and readily burned when the lighted match approached it.

FLASH AND BURNING POINTS OF KEROSENE-GASOLINE MIXTURES

Since so little is said in the literature about the effects of highly volatile petroleum fractions upon the flash and burning point constants of ordinary kerosene, we have determined the influence upon them in the case of a kerosene mixed with "low-test" gasoline, "high-test" gasoline and "petroleum ether." Both the open and closed cup methods were used for flash point determinations.

The open cup test depends not only upon the skill of the operator but also the condition of the atmosphere, and is affected by the slightest current of air. It is a reliable test, however, for such cases where an oil will be heated in open vessels to determine to what degree it can safely be heated without ignition by flame. With such a case the open test is an actual imitation of the real conditions and therefore fully warranted.

The flash point of kerosene should be high enough so that it will insure safety when the kerosene is burned in a lamp. Danger from a petroleum lamp can occur if the flame flashes back into the petroleum reservoir by accident or carelessness and ignites the vapors which had accumulated in the closed basin. (*Proc. Am. Soc. Testing Materials*, vol. 10, p. 464, 1910.)

The Foster cup method is the standard method for determining the flash point of kerosene prescribed by the law in Ohio, which states that kerosene shall not flash below 120 deg. F. by this method. (Allen's "Commercial Organic Analysis," 3d ed., p. 127.)

METHOD OF USING OPEN CUP PROCEDURE

For determining the open cup flash and burning points an apparatus similar to the Cleveland open cup was used, with the addition of a casing to more efficiently prevent drafts of air. A sketch of this apparatus is shown in Fig. 3. It consisted of a 40 cc. nickel crucible A, whose upper surface measured about 4 cm. in diameter. This was placed inside a large 120 cc. nickel crucible B, which contained sand to a depth of about 2 cm. This sand bath was then supported in the flame guard C by means of the asbestos board D, which had a hole cut in its center to admit B as shown. The flame protector was supported on the tripod stand E. Heat was supplied by the bunsen burner F as shown. The whole apparatus was protected from air current by the casing of thin sheet copper G. A thermometer was held suspended in the oil by means of a burette clamp on a ring stand. An ordinary mouth blow pipe connected to the gas cock by rubber tubing was used as a tip for the flame to be passed over the oil.

After thoroughly shaking the oil sample, the small crucible was filled to within $\frac{1}{2}$ cm. of the brim. This required 32 cc. The thermometer was then lowered by sliding the burette clamp on the ring stand. The thermometer was held at such a height by the clamp that when the clamp was lowered to the top of the copper shield the bulb was totally immersed in the center of the oil to the same depth each time. Heat was then applied by means of the bunsen burner, so that the temperature rose at the rate of 5 deg. C. per min. The test torch was then lighted and the flame made $\frac{1}{2}$ cm. in length. As the flash point was approached, for every degree rise in temperature the flame was passed slowly over the cup horizontally about 1 cm. above the surface of the oil and near the thermometer.

After obtaining the flash point, the test flame was still passed over the oil in a similar manner until the oil permanently ignited. The thermometer was then quickly raised from the oil and the flame in the cup extinguished by excluding the air by means of a solid piece of asbestos board placed over the cup.

All open cup temperatures were read on a 400 deg. C. thermometer. The calibration of this thermometer was checked up by comparing its two fixed points 0 deg. and 100 deg. C. with a standard thermometer. To fix

the zero point, the thermometer was surrounded by melting ice and the reading compared with that of the standard thermometer under the same conditions.

The 100-deg. point was then determined by placing the bulb of the thermometer used in the neck of an Erlenmeyer flask containing boiling water so that it was entirely surrounded by steam and the reading on the thermometer was noted in comparison with that of the standard thermometer under like conditions. The barometer reading was also taken and corrections applied. The uniformity of the bore was checked up by detaching a thread of mercury and measuring its length throughout different portions of the stem between 0 deg. and 300 deg. Required corrections were applied throughout all of the work.

For each succeeding test the warm sand from the test preceding was emptied from the cup and fresh sand put in, so that all tests were made under exactly the same conditions. The cup was then cooled by immersion in cold water and thoroughly dried.

In testing mixtures where the flash point was below room temperature, the sand was omitted from the bath, and cracked ice, or ice plus calcium chloride, when necessary, was substituted. Cases where this was required are marked on the table by an asterisk (*).

METHOD OF USING CLOSED CUP PROCEDURE

A standard Foster cup apparatus was used. Its thermometer was checked against U. S. Bureau of Standards thermometer No. 4576. The method of procedure in determining the flash point by the Foster cup was as described in Stillman's "Engineering Chemistry," pp. 448-449. This was as follows: The thermometer with its mounting was removed from the oil cup. The oil cup containing the flashing taper was removed and the open water bath half filled with water. The flashing taper was then removed from the cup and, after thoroughly shaking the oil in its container, it was carefully poured into the cup at the place of the flashing taper wick holder until it just reached the gage mark at the thermometer hole. The cup was then tipped so that the oil flowed away from the gage, and was then gradually restored to the horizontal position. If the surface again adhered to the mark, it was all right; in case it did not, a little more oil was added. The flashing taper was then adjusted to give a flame $\frac{1}{4}$ in. in height. The oil cup was now set in the water bath, the flashing taper returned to its place, the conical thimble inverted around it and the thermometer returned to its place upon the cup, care being taken that the latter was pushed down upon the cup as far as possible. The lamp beneath was half filled with alcohol, lighted, and placed beneath the water bath. The wick was so adjusted that the temperature of the oil was raised at the rate of 2 deg. F. per min. When the thermometer read 90 deg. the flashing taper was lighted and closely observed. In tests where the flash point was 90 deg. or lower, the flashing taper was placed in the cup before applying heat from below. In several instances, as previously mentioned in the open cup method, the mixtures flashed below room temperature. In these cases cracked ice was placed in the water bath and the test repeated. These cases are shown by an asterisk (*) in the tables.

A rather peculiar phenomenon took place in the closed cup flash test. When the oil was previously cooled by ice, it flashed some 5 or 6 deg. higher than when not

previously cooled. Thus, in the case of the 7½ per cent mixture of high-test gasoline and kerosene when ice was not used in the bath it flashed at 75 deg. F. (as soon as the pilot was lighted). However, when previously cooled by ice, the mixture had to be heated to 84 deg. F. before flashing, the pilot burning constantly. This may be due to the design of the cup. The flashing taper when in place forms a draft so that when lighted while the oil was below 75 deg. the volatile gases liberated would pass out through the opening and escape, whereas when no light was present the draft was not so great and consequently the concentration of highly volatile vapors in the cup would be greater, so that when a flame was admitted at 75 deg. the concentration of the gases was enough to extinguish it.

All flash points in both open and closed cup have been corrected for normal barometric pressure, 760 mm., by Table I (U. S. Bureau of Mines Technical Paper No. 49). In order to show to what extent the barometric pressure affects the flash point, the solid curves

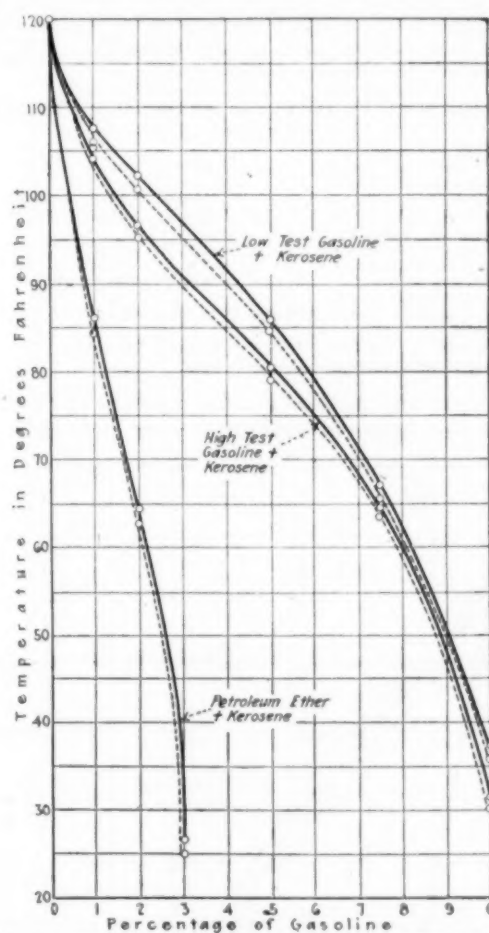


FIG. 4. FLASH POINTS OF GASOLINE-KEROSENE MIXTURES—OPEN CUP METHOD

have been drawn which represent the flash points when corrected for barometric pressure and the dotted curves which do not include barometric pressure correction.

No corrections for pressure have been applied to the burning point results, as no correction table was available.

The kerosene before being used in these tests was filtered through filter paper to remove all traces of moisture fog.

DISCUSSION OF RESULTS

The tables and accompanying Figs. 4, 5 and 6 show the results obtained by these tests. Blank spaces in

the tables show that the tests were either unable to be carried out because of the low temperature required or the test was considered unsafe.

FLASH AND BURNING POINTS OF "LOW-TEST" GASOLINE AND KEROSENE

Gasoline by volume, per cent.....	0	1	2	5	7.5	10
Kerosene by volume, per cent.....	100	99	98	95	92.5	90
Open cup flash point, deg. F.:						
Without barometric correction.....	118.4	105.8	100.4	84.2	65.3*	35.6*
With barometric correction.....	120.0	107.4	102.0	85.8	67.0*	37.2*
Foster cup flash point, deg. F.:						
Without barometric correction.....	128.9	119.3	114.5	95.0	88.6*	.....
With barometric correction.....	130.5	120.9	116.1	96.6	90.2*	.....
Burning point, deg. F.....	134.6	125.6	122.0	112.1	99.5*	78.8*
Gasoline used: "Low-test,"						
Specific gravity = 0.738 = 59.7 deg. B. at 15.5 deg. C.						
Kerosene used:						
Specific gravity = 0.815 = 41.8 deg. B. at 15.5 deg. C.						
Shows that freezing mixture was used in bath.						

FLASH AND BURNING POINTS OF "HIGH-TEST" GASOLINE AND KEROSENE

Gasoline by volume, per cent.....	0	1	2	5	7.5	10
Kerosene by volume, per cent.....	100	99	98	95	92.5	90
Open cup flash point, deg. F.:						
Without barometric correction.....	118.4	104.0	95.0	78.8	63.5*	30.2*
With barometric correction.....	120.0	105.3	96.3	80.1	64.8*	31.5*
Foster cup flash point, deg. F.:						
Without barometric correction.....	128.9	118.3	114.0	90.5	82.6*	.....
With barometric correction.....	130.5	119.6	115.3	91.8	83.9*	.....
Burning point, deg. F.....	134.6	118.8	114.8	105.8	95.0*	71.6*
Gasoline used: "High-test,"						
Specific gravity = 0.703 = 69.15 deg. B. at 15.5 deg. C.						
Kerosene used:						
Specific gravity = 0.815 = 41.8 deg. B. at 15.5 deg. C.						
* Shows that freezing mixture was used in bath.						

FLASH AND BURNING POINTS OF PETROLEUM ETHER AND KEROSENE

Petroleum ether by volume, per cent.....	0	1	2	3
Kerosene by volume, per cent.....	100	99	98	97
Open cup flash point, deg. F.:				
Without barometric correction.....	118.4	84.2	62.6*	24.8*
With barometric correction.....	120.0	85.8	64.2*	26.4*
Foster cup flash point, deg. F.:				
Without barometric correction.....	128.9	103.7	77.3*	.....
With barometric correction.....	130.5	105.3	78.9*	.....
Burning point, deg. F.....	134.6	118.4	105.8*	87.8*
Petroleum ether used:				
Specific gravity = 0.635 = 89 deg. B. at 15.5 deg. C.				
Kerosene used:				
Specific gravity = 0.815 = 41.8 deg. B. at 15.5 deg. C.				
* Shows that freezing mixture was used in bath.				

In the open cup method the flash points of the "high-test" gasoline-kerosene mixtures were naturally lower

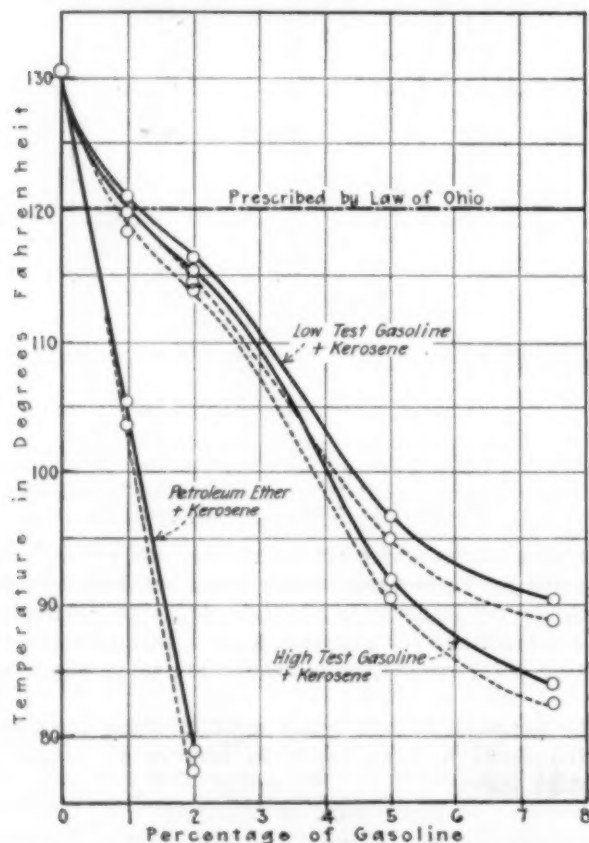


FIG. 5. FLASH POINTS OF GASOLINE-KEROSENE MIXTURES—FOSTER CUP METHOD

than the corresponding mixtures of "low-test" gasoline, being a minimum of 2.1 deg. F. less at 1 per cent and 7.5 per cent gasoline and a maximum of 5.7 deg. F. less at 10 per cent gasoline. The fact that a minimum difference occurred at both 1 per cent and 7½ per cent shows that the open cup flash point of the "low" and "high" test gasoline-kerosene mixtures did not fall at the same rate with increase in percentage of gasoline.

In the case of the closed cup the flash points for mixtures above 2 per cent high and low test gasoline regu-

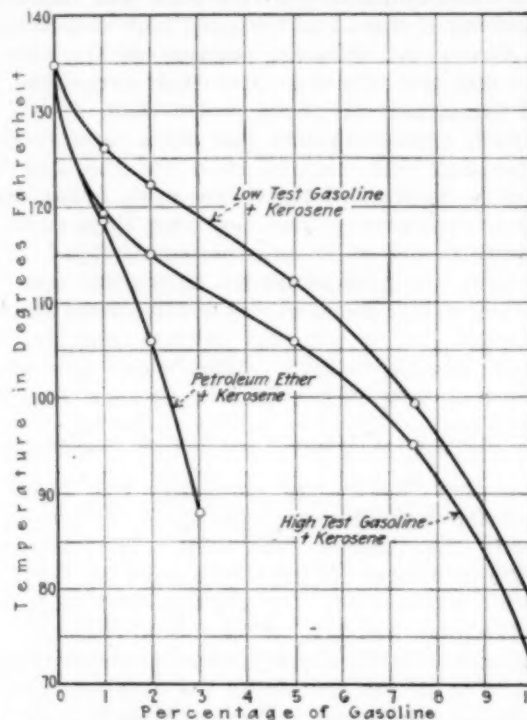


FIG. 6. BURNING POINTS OF GASOLINE-KEROSENE MIXTURES

larly fall at different rates, with increase in concentration of gasoline as shown by the curves falling away from one another. This shows that the open cup method does not bear a constant relation to the closed cup method, or, graphically speaking, their curves are not the same shape.

The flash point of the petroleum ether-kerosene mixtures decreased regularly with increase in concentration of petroleum ether so that in the case of the open cup method the curve was almost a straight line, and in the case of the closed cup method it was a straight line.

The lowering in the flash point of kerosene by adding petroleum ether was remarkable. In the open cup method 2.9 per cent petroleum ether lowered the flash point of the kerosene about 88.5 deg. F. or as much as for 10 per cent high-test gasoline. In the case of the closed cup method 1.8 per cent petroleum ether lowered the flash point about 47 deg. or the same as for 7.5 per cent of high-test gasoline.

The decrease in the open cup flash points for the gasoline-kerosene mixture was somewhat over 1.3 times as much as the decrease in the burning point for the same concentration of gasoline. For example, 10 per cent low-test gasoline lowered the flash point 82.8 deg., whereas it lowered the burning point but 55.8 deg.; 10 per cent high-test gasoline lowered the flash point 88.2 deg. and the burning point 63.0 degrees.

In the case of the petroleum ether-kerosene mixtures the flash point was lowered just about twice as much

as the burning point, e.g., 3 per cent petroleum ether lowered the flash point 93.6 deg. and the burning point only 46.8 degrees.

The burning point curves are of about the same shape as the open cup flash point curves, showing that in the case of the high and low test gasoline-kerosene mixtures the burning points did not decrease at the same rate as each other. In making up mixtures, the order of addition did not affect results, though such a difference is possible for a time at least on a larger scale.

It is evident that the flash and burning points of kerosene are greatly reduced by small admixtures of more volatile petroleum fractions, such as gasoline, so that grave danger can easily result therefrom.

DISTILLATION TESTS OF FRACTIONS USED

In order that the oils used in this work may be identified the specific gravity was determined by the hydrometer method and distillation cuts of the oils obtained.

The distillations were carried out as prescribed in Technical Paper 166 of the Bureau of Mines, with the addition of reading the number of cubic centimeters

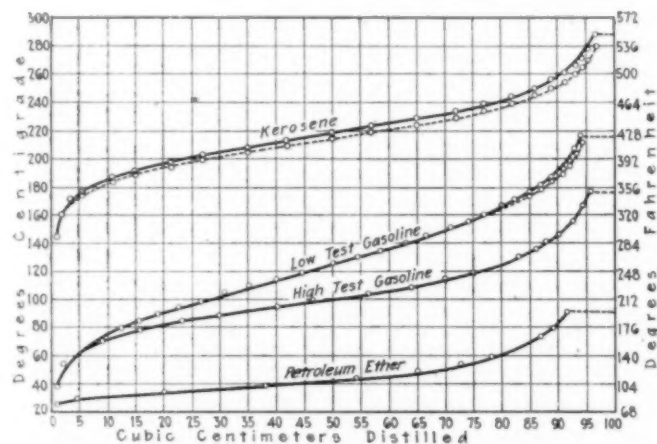


FIG. 7. DISTILLATION CURVES OF THE OILS TESTED

distilled every 5 deg. rise in temperature as recorded by the thermometer as well as readings at every 10 per cent by volume.

The 250 cc. flask connected with the condenser was filled with 100 cc. of the oil measured in a 100 cc. cylinder. The same cylinder was then used as the receiving vessel. In the kerosene and gasoline distillation the flask was covered with an asbestos box; this being omitted in the distillation of the petroleum ether. Heat was applied so that the distillation proceeded at the rate of about 5 cc. per min., the entire distillation requiring about 25 min. The thermometer used in these distillations was the same as that previously described as being used for the open cup flash and burning point determinations. Besides applying the calibration correction, a correction was added for the emergent stem of the thermometer, varying up to 2.5 deg. C. Formula for corrections was obtained from "Physico Chemical Tables," Castell Evans, vol. 1, p. 126, J. B. Lippincott Co., Philadelphia, Pa. The condenser trough was filled with cracked ice to insure complete condensation. There were from 2 to 3 cc. of residue left in the flask at the end of each distillation. The results obtained by the distillation are shown in the tables and curves following. Fig. 7 contains all of the oils in order that a comparison may be made between them.

No stem temperature correction was necessary in the case of the distillation of the petroleum ether, since the last fraction boiled off at 103 deg. C. as recorded by the thermometer and the emergent stem began at 105 deg. C. in all cases.

The solid curve represents the distillation when stem temperature corrections have been applied. The dotted curves represent the distillation without stem temperature correction.

E. W. Dean in his report on gasoline distillation (Bureau of Mines Technical Paper 214, p. 29) plots the dry point on the 100 cc. ordinate. This is not exactly correct, since the dry point is always obtained before 100 cc., the initial volume of gasoline, has been received. Plotting this results in the curve ending in a sharper bend than it should. To obviate this error, we have plotted the actual dry point on the curve where it is observed and extended a straight horizontal dotted line to the 100 cc. ordinate in order to show where the curve would come had Dean's method of plotting been used. This actually represents approximate loss in distillation.

For convenience, the ordinates are labeled both in Centigrade and Fahrenheit readings.

Temperature, Deg. C. Deg. F.	Kerosene, cc.	Low-Test Gasoline, cc.	High-Test Gasoline, cc.	Petroleum Ether, cc.
24	75.2			1.0
29	84.2			4.5
34	93.2			20.0
38	100.4	1.0		
39	102.2			38.0
41	105.8		1.0	
44	111.2			54.0
49	120.2	1.5		65.0
54	129.2	2.0		72.5
59	138.2	3.0		78.0
64	147.2	5.0	4.0	
69	156.2	9.0	5.5	
71	159.8		10.0	
74	165.2	10.5		87.0
79	174.2	12.5	15.5	89.0
84	183.2	15.5	23.0	90.0
89	192.2	19.0	30.0	91.0
92	197.6			91.5
94	201.2	22.5	40.0	
99	210.2	26.5	46.5	
104	219.2	30.5	56.5	
109.2	228.6	35.0	64.0	
114.2	237.6	40.0	70.0	
119.3	246.8	44.5	75.0	
124.5	256.1	50.0	81.0	
129.6	265.3	54.5	83.0	
134.7	274.5	58.5	86.0	
139.8	283.7	63.0	88.0	
145.0	293.0	66.5	90.0	
149.1	300.4	71.0	92.0	
155.3	311.5	74.0	93.0	
160.4	320.7	77.0	94.0	
165.6	330.1	80.0	94.5	
170.8	339.4	82.0	95.0	
175.9	348.7	85.0	96.0	
181.2	358.2	8.5	87.0	
186.3	367.3	11.0	89.0	
191.5	376.7	15.0	91.0	
196.7	386.1	21.5	92.0	
201.9	395.4	27.0	92.5	
207.1	404.8	35.0	93.0	
212.4	414.3	42.0	93.5	
217.7	423.7	50.0	95.0	
222.8	433.2	57.0		
228.1	442.5	65.0		
233.4	452.1	72.0		
238.7	461.7	77.0		
244.0	471.2	82.0		
249.3	480.7	86.0		
254.6	490.3	89.0		
260.0	500.0	91.5		
265.3	509.5	93.5		
270.3	518.5	94.5		
275.7	528.2	95.5		
281.3	538.3	96.0		
286.9	548.4	97.0		

DISTILLATION TESTS IN 10 PER CENT CUTS

	Petroleum Ether	High-Test Gasoline	Low-Test Gasoline	Kerosene
* Deg. C. Deg. F.	Deg. C. Deg. F.	Deg. C. Deg. F.	Deg. C. Deg. F.	Deg. C. Deg. F.
10	31.0 87.8	71.0 159.8	73.0 163.4	185.0 365.0
20	34.0 93.2	83.0 181.4	90.0 194.0	195.6 384.1
30	36.5 97.7	89.0 192.2	103.7 218.6	204.2 399.5
40	39.5 103.1	94.0 201.2	114.2 237.6	210.3 410.4
50	43.0 109.4	101.0 213.8	124.4 256.1	217.6 423.6
60	47.0 116.6	106.0 222.8	136.7 278.0	225.1 437.0
70	52.0 125.6	114.2 237.6	149.0 300.2	232.3 450.1
80	61.0 141.8	123.9 255.0	165.6 330.1	241.5 466.6
90	84.0 183.2	145.0 293.0	190.0 374.0	256.9 494.5

* Volume in Percentage

We are indebted to Mr. Frank C. Vilbrandt, instructor of industrial chemistry in this laboratory, for material assistance in the search of the literature for data covering the ground of this report and kindred topics.

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The Liability for Infections*

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THE workmen's compensation acts have brought many new problems as to their own liability before employers. Not only that, but they have caused no amount of uncertainty among courts as to just what this liability amounts to.

The compensation acts serve to secure the payment of compensation to workmen who are incapacitated by means of an accidental injury "arising out of and in the course of" the employment. This naturally limits the employer's liability somewhat, but at the same time it raises a point of controversy over what is meant by the term "accident."

The courts have decided, and with good judgment, that the meaning to be given the word accident shall be its ordinary and usual meaning and that it cannot be given a technical meaning if the ultimate purpose of the compensation acts is to be kept in mind and preserved. So, they have said that an accident is any unlooked for and untoward event happening within chance and without design or intention. If a workman suffers such an accident which arises through the employment and out of it, then he is clearly entitled to compensation.

But it is the fitting of specific cases that come up to the studied expression of the statutes and of judicial opinions that causes the real difficulty. For instance, the question of whether an infection is an accident or not has caused no end of litigation under the acts.

*It is a well-known fact that workmen engaged in certain occupations are constantly subjected to the hazard of infection. Those who work with paint and stains are in constant menace; those who work in refuse and débris are constantly in danger of experiencing blood poisoning, and those engaged in certain

other specific occupations are constantly subjected to the danger of infection through both the blood and the lungs by reason of the materials they work with, the fumes they breathe, or the inherent nature of the work. The long list of cases being reported each year on this subject alone is ample authority for this statement.

In the earlier days of the compensation practice the courts were called upon almost in the first cases to decide whether or not diseases were accidents. They held in diverse opinions that they were and they were not accidents. These decisions have since given rise to a series of rules which are more or less authoritative and which embody the present law upon the subject.

Unless specifically provided for in the statute, an occupational or industrial disease is not an accident within the meaning of the compensation acts. As to what constitutes an occupational disease there may be some doubt, but the courts have pretty well defined it.

One authority states: "An occupational disease is a disease caused by or especially incident to, a particular employment."

In a New York case, the court said: "An accidental injury . . . is clearly distinguishable from an injury in the nature of a vocational disease, sustained in the course of the employment, where, from the inherent nature of the work, disease is likely to be contracted."

TRAUMATIC DISEASE

It is well known that where certain work is followed certain diseases are very apt to be contracted if the workman persists in following that employment very long. Among the most common of these diseases are various forms of poisoning such as lead and copper poisoning. Since these diseases are of an inherent danger to the work, the courts have almost uniformly held that they are not an "accident" and the workman is not entitled to compensation,

*Other articles by this author on the same general subject have appeared in *CHEM. & MET. ENG.* as follows: "The Explosion of Chemicals—Common Law Liability," Vol. 21, No. 2, July 15, 1919, p. 83; "The Explosion of Chemicals—Workmen's Compensation Acts," Vol. 21, No. 3, Aug. 1, 1919, p. 131.

unless the act specifically mentions occupational diseases, in case he suffers from one.

The rule, however, is different in Massachusetts and other States where the compensation is payable not for accidental injuries, but for "personal injuries." The court of Massachusetts has said that an occupational disease is a personal injury within the meaning of the Massachusetts act. This does not say, however, that all diseases are deemed to be non-compensable in the opinion of the courts. While occupational diseases are excluded because they form a distinct class of their own, there has been a clear reservation on the part of other, ordinary forms of diseases.

The rule is well settled that if the disease is clearly the result of the employment, or that the employment subjected the workman to a greater hazard to the disease than he would have been subjected to in ordinary employment, or if the disease resulted from an accidental injury, then the workman will be entitled to compensation. This is what is known as the "traumatic disease" theory. If the disease has its origin in trauma, or injury, then it is clearly an accident within the meaning of the acts. For instance, a workman falls off a trestle or a train of cars and because of his injuries and bruises about the chest contracts pneumonia. This is a compensable disease within the meaning of the compensation acts.

Or, another illustration: A workman is required to work for several hours in cold water in order to save a levee or other property of his employer from damage or destruction. Because of the unusual exposure he contracts pneumonia. This is a compensable disease within the meaning of the compensation acts.

INFECTION CASES MORE DIFFICULT

Still another case might be given: A workman is required to clean up debris following a wreck. He scratches his hands and contracts blood poisoning from handling the debris and refuse matter. This is a compensable disease within the meaning of the compensation acts.

Infection, because of its nature, is often a harder matter to determine than a mere disease. An infection, being of such slow and insidious origin that it is extremely difficult to trace it, presents an entirely different problem than an ordinary disease, the symptoms of which generally have their root in some event or happening within the employment. A workman may be able to determine, from his exposure and the like, where he got his disease, but not be able to state just where he got his infection.

It is necessary, however, that the infection be linked up to the employment by some certainty as to time and place and the circumstances under which it was acquired. Generally, employers resist claims for blood poison, for instance, unless the workman reports every little scratch and cut he receives *at the time*. It is so easy for one to pick up such infections outside the employment that employers are certainly justified in taking these steps for self-protection.

Where the employment is clearly to blame for certain infections, however, the courts will not be too technical in their requirements. In one case a workman employed to mow weeds along a right of way contracts poisoning on his hands and face. He was

allowed compensation, it not being necessary for him to prove specifically the exact instance when he encountered the poisonous substance which incapacitated him.

The compensation acts are administered in a "spirit of true helpfulness" whenever possible, and they will include infections and diseases within the limitations mentioned above.

Ammonia in Producer Gas*

By F. K. OVITZ

Assistant Chemist, Bureau of Mines

THE tests described in this paper were made at factory No. 2 of the Hazel-Atlas Glass Co., Washington, Pa., in co-operation with Mr. C. E. Frazier and Mr. C. D. Smith of that company. The object of the tests was to determine the amount of ammonia in gas from producers of the Smith type. At the time the tests were made the importance of ammonia for munitions, refrigeration and agriculture made it desirable that all possible sources of supply should be utilized.

For ammonia-recovery, gas-producers can be divided into two general classes.

1. Producers gasifying the fuel at a low temperature with a comparatively large amount of steam, 3 to 4 lb. of steam per lb. of coal.

2. Producers gasifying the fuel at a high temperature and using a comparatively small amount of steam, about 1 lb. per lb. of fuel.

From the first, or Mond type, 15 to 20 lb. of ammonia, (NH₃), or 60 to 80 lb. of ammonium sulphate, (NH₄)₂SO₄, can be recovered per ton of bituminous coal. Information on the quantity of ammonia in gas from the second type, to which the Smith producer belongs, was not available.

DESCRIPTION OF TESTS

The producer plant consists of five producers with inclined grates, each grate having a projected area of 200 sq.ft. The coal is fed into the top of the producer through hoppers which are arranged so that they will distribute it uniformly over the top of the fuel bed. The thickness of the fuel bed during the tests was about 5 feet. The bed was kept in good condition and as free as possible from holes by hand-poking.

The coal used was from the Pittsburgh bed in Washington County, Pa., and contained about 1½ per cent of nitrogen on the moisture and ash-free basis. The size was not uniform; at times fairly clean coal of No. 1 nut size was used, while at other times a large amount of fine coal was mixed with it.

Air saturated with steam at 150 to 160 deg. F. was used to gasify the coal, about 4 lb. of air and 1 lb. of steam being used for each pound of coal. The gas was cleaned before being used. From each producer the gas passed through a "hot pipe" into a "down-comer," from which it entered the bottom of a primary scrubber, where it was cooled to about 140 deg. F. by water sprays. From the top of the primary scrubber the gas passed into a large header, where gas from all the producers mixed to some extent. From this header it was sent by exhausters through the tar filters and finally through the secondary scrubbers, where it was washed with water again and cooled to about 100 deg. F. and then delivered into the gas main.

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The water used in the system was cooled in a spray pond and recirculated. The water and tar from the scrubbers and that collected in the header ran into a common drain which emptied into the tar well, where tar was separated from the water. The water was pumped from the tar well to the spray pond, where it was cooled and then returned to the scrubbers.

Gas from a single producer was used for most of the tests. For total ammonia in the gas an open-end sampler was placed in the "hot pipe" about 5 ft. from where the gas left the producer. The sample of gas was passed through the following system to absorb the ammonia and measure the volume:

1. Bottle which served as a trap for condensed water and tar.
2. Four wash-bottles containing dilute sulphuric acid.
3. Filter made from asbestos fiber.
4. Experimental wet meter.

Suction was supplied by a small steam aspirator. The first two tests showed that it was very important to collect all the water which condensed from the gas because a considerable part of the ammonia was dissolved in it. For this reason in subsequent tests bottle No. 1 was arranged so that moisture and tar which condensed in the sampler could drain into it. To determine volatile and fixed ammonia, distilled water was used in the wash bottles in place of dilute sulphuric acid. Gas was drawn through the apparatus at a rate of about 1 cu.ft. per hour.

The liquid from all the bottles was made up to a definite volume. The ammonia in an aliquot part of this volume was determined by adding strong caustic soda solution, distilling and absorbing the ammonia in a measured volume of standard decinormal sulphuric acid. The acid which was not neutralized by ammonia was titrated with standard decinormal caustic soda using cochineal as indicator. The quantity of ammonia per ton of coal was calculated from the results of the titration and the volume of gas produced, by means of the formula given below. While no exact measurement of the quantity of gas produced per ton of coal could be made, 130,000 cu.ft. is assumed for the purpose of making the calculations and is believed to be sufficiently accurate for practical purposes. The weight of ammonia multiplied by 3.8787 gives the weight of ammonium sulphate per ton of coal.

$$\frac{\text{cc. of N/10 acid} \times 0.0017 \times 130,000}{\text{cu.ft. of gas in sample} \times 453.6} = \frac{\text{lb. NH}_3 \text{ per ton}}{\text{of coal}}$$

The quantity of ammonia in the gas at various points

in the system is given in Table I. All gas volumes are expressed in cubic feet at 60 deg. F. and 30 in. of mercury. Tests Nos. 1 and 2 were made with a large tar filter in front of the wash bottles and the results given on these are low, due to condensation of water vapor from the gas and absorption of ammonia by it. These results should not be used in computing averages. Tests Nos. 7, 9, 10, 11, 12 and 13 were made with distilled water in wash bottles in order that the proportions of fixed and volatile ammonia can be determined.

In addition to the quantity of ammonia in the gas, the percentage of ammonia in the liquor from the tar well and spray pond was determined. The results of these determinations are given in Table II.

An average of 5.70 lb. NH_3 , or 22.11 lb. ammonium sulphate, was found in the raw gas as the result of seven tests. While the variation between individual tests was quite large, it was no greater than might be expected on account of the changing conditions in the producers during the time tests were being made.

TABLE II. AMMONIA IN LIQUOR FROM TAR WELL AND FROM SPRAY POND

Liquor	Specific Gravity at 15 Deg. C.	Free NH_3 per Cent by Weight	Total NH_3 per Cent by Weight
Tar well.....	.....	.....	0.614
Tar well.....	1.018	0.057	0.732
Spray pond.....	1.017	0.072	0.687

No detailed study was made of the effect of these changing conditions on the amount of ammonia in the gas, but by watching the variations which occurred in the experimental results and the condition of the producer, it was apparent that the temperature in the top of the producer was a very important factor. The rate of gasification and the amount of steam used, within the limits of daily variation, did not affect results noticeably. Whatever effect these factors had was less than that due to the temperature of the top of the producer.

The temperature in the top of the producer appeared to be influenced by the condition of the fuel bed more than by any other factor. If the fuel bed was not kept free from holes, unconsumed air passed through it and the oxygen burned with gas in the top of the producer, thereby raising the temperature. It required almost constant attention to keep the fuel bed free from holes, and at times it was impossible to do so. Since high temperatures are unfavorable to the formation and production of ammonia, it is very necessary to maintain as low a temperature as possible in the top of the producer

TABLE I. AMMONIA IN GAS

Test No.	Description of Sample	Volume of Gas Used Cu.Ft. at 60 Deg. F. and 30 In. Hg. Saturated With Water	Yield in Ammonia—Lb. per Ton of Coal					
			Total		Free		Fixed	
			As NH_3	As $(\text{NH}_4)_2\text{SO}_4$	As NH_3	As $(\text{NH}_4)_2\text{SO}_4$	As NH_3	As $(\text{NH}_4)_2\text{SO}_4$
1a	Raw gas from "hot pipe".....	4.253	0.65	2.52	.....	.....	.....	.....
2a	Raw gas from "hot pipe".....	15.636	2.30	8.92	.....	.....	.....	.....
3	Raw gas from "hot pipe".....	25.249	5.41	20.98	.....	.....	.....	.....
4	Raw gas from "hot pipe".....	20.638	6.72	25.96	.....	.....	.....	.....
5	Raw gas from "hot pipe".....	22.832	4.34	16.83	.....	.....	.....	.....
6	Raw gas from "hot pipe".....	38.424	5.77	22.38	.....	.....	.....	.....
8	Raw gas from "hot pipe".....	13.310	6.25	24.24	.....	.....	.....	.....
7b	Raw gas from "hot pipe".....	25.377	6.38	24.75	4.96	19.24	1.42	5.51
10b	Raw gas from "hot pipe".....	33.987	5.00	19.39	3.78	14.66	1.22	4.73
9b	Clean gas from main.....	25.746	0.41	1.59	0.40	1.55	0.01	0.04
11b	Clean gas from main.....	16.423	.....	.....	0.41	1.59	.....	.....
12b	Gas before entering secondary scrubber.....	11.576	2.57	9.96	2.46	9.54	0.11	0.43
13	Gas after passing primary scrubber.....	19.501	.....	.....	2.10	8.15	.....	.....

a Tests 1 and 2 made with large filter, not used in calculating average results.

b Test made with distilled water in wash bottles.

in order to obtain the best yield of ammonia. The quantity of ammonia found in the gas from one ton of coal was of the same general magnitude as is obtained from the carbonization of one ton of coal in a retort or by-product coke oven. This seems to indicate that the ammonia obtained comes from the destructive distillation of the coal taking place at the top of the fuel bed, and that very little comes from nitrogen liberated during gasification of the fixed carbon. If ammonia is formed from nitrogen liberated during gasification of the fixed carbon, it is apparently broken up by the passage through the hot fuel bed before reaching the top.

Between 20 and 25 per cent of the total ammonia is in the form of fixed ammonia salts and the remainder is in the form of volatile or free ammonia.

Practically all of the fixed ammonia is absorbed in the water used for scrubbing the gas and accumulates in the pond liquor. Most of it is absorbed before the gas reaches the secondary scrubber, as shown by test No. 12. At the time of the tests the quantity of ammonia in the tar well and pond liquor averaged 0.678 per cent by weight, practically all of it being fixed ammonia. This percentage varies from day to day with the quantity of water in the pond. When fresh water is added to the pond to make up for loss by evaporation, the percentage decreases temporarily, but the total quantity in the pond increases steadily in proportion to the volume of gas scrubbed by the liquor.

Practically all of the volatile ammonia is absorbed in the scrubbing water and later dissipated into the air at various points throughout the system. Tests Nos. 9 and 11 show that the cleaned gas contained only about 0.4 of a pound of ammonia per ton of coal, practically all of which was in the volatile form. The exact distribution of the volatile ammonia was not determined. It depends upon the temperature of the scrubbing water at different points in the system and varies from day to day with the changes in these temperatures and the quantity of water.

It is possible to recover practically all of the ammonia in the gas, either by cooling sufficiently and scrubbing with cold water, or by treating with sulphuric acid. However, because of the low concentration of the ammonia in the gas, less than one-tenth that of by-product oven gas, and the large volume that consequently must be treated per lb. of ammonia recovered, the cost of equipment and recovery would be high. For example, to obtain the ammonia from one ton of coal used in a gas producer, about 130,000 cu.ft. of gas would need to be treated, whereas if the coal were used in a gas retort or by-product oven, about 10,000 cu.ft. would have to be treated and the quantity of ammonia recovered in both cases would be approximately the same. The fixed ammonia, amounting to about 1.25 lb. per ton of coal, can be recovered by distilling the pond liquor with lime.

House Passes Tungsten Protection Bill

On Aug. 21 the House of Representatives passed the Timberlake bill providing for a tariff of \$10 a unit on tungstic oxide, which amounts to \$10 a ton on crude tungsten. Manufactured tungsten products must pay twice the amount, or \$1 per lb. This tariff, in addition to the estimated import price of \$8 to \$10, will fix American tungsten at \$18 to \$20 and thus enable domestic producers to compete with imported ore from China and South America, upon which there is no tariff at present.

Recent Chemical and Metallurgical Patents

Complete specifications of any of the United States patents abstracted herein may be obtained by remitting 5c. each to the Commissioner of Patents, Washington, D. C.

Utilization of Tin Scrap.—A method of separating iron and tin based upon the fractional distillation of their chlorides is employed by DANIEL A. and SIDNEY H. WILCOX of Garden City, N. Y., for the utilization of tin scrap. The scrap is compressed and heated in a suitable furnace to such a temperature that a vigorous reaction ensues when chlorine is passed over the metal, both metals being volatilized as chlorides. Or, the scrap may be melted and the chlorine passed through or over the melted metal contained in a bessemer converter, reverberatory, cupola or blast-furnace, electric melting furnace or muffle furnace. In either case, the mixed chlorides are separated by fractional condensation. The tin chloride may be converted into metallic tin or tin oxide by well known methods. The ferric chloride is dissolved in water, reduced to ferrous chloride by passing the solution over hot iron and electrolyzed, using insoluble electrodes, so that the products are pure iron (some occluded hydrogen is present, but this may be removed by heat) and chlorine gas, which may be utilized for the treatment of additional quantities of scrap. (1,310,381; July 15, 1919.)

Method of Producing Lead Salts.—RALPH M. HARRINGTON has developed an electrolytic method for producing white lead and other lead salts. White lead similar to that produced by the "Dutch process" may be produced in the apparatus here illustrated. A cell (1) with anode (2) and cathode (3); the

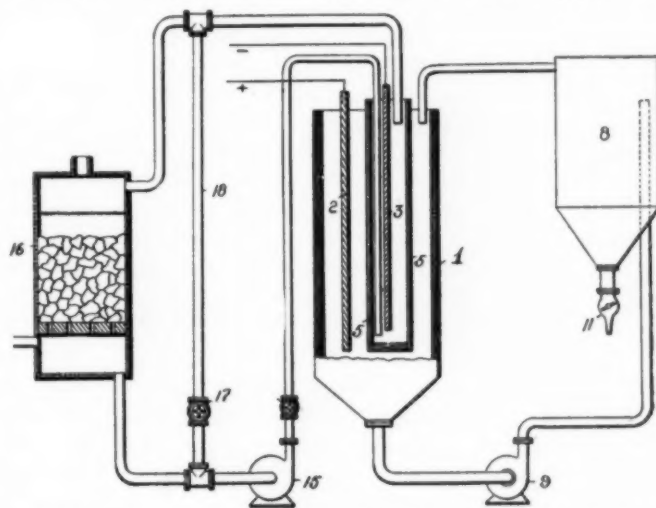
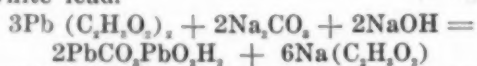


DIAGRAM SHOWING ELECTROLYTIC METHOD OF PRODUCING LEAD SALTS

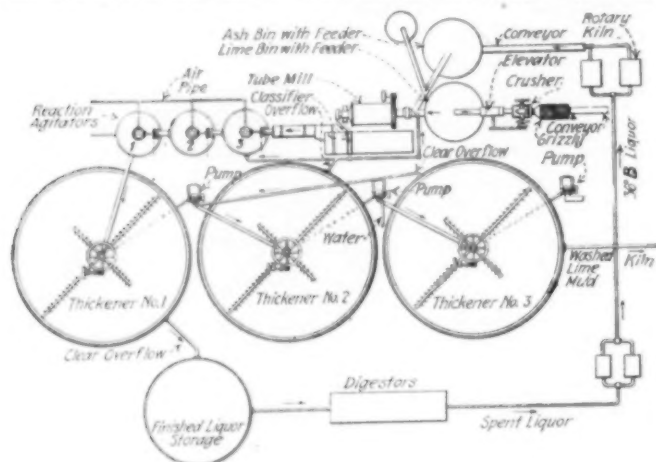
cathode is surrounded by a diaphragm (5). The anolyte is a solution of sodium acetate, the catholyte contains in addition sodium hydroxide, carbonate and bicarbonate. The passage of a current through the cell produces lead acetate at the anode and sodium hydroxide at the cathode, thus, $2\text{Na}(\text{C}_2\text{H}_3\text{O}_2) + \text{Pb} = \text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 + 2\text{Na}$ and $\text{Na} + \text{H}_2\text{O} = \text{NaOH} + \text{H}$. The catholyte is circulated by the pump (15) to a carbonating tower (16), where it meets a current of CO_2 . The NaOH produced at the cathode and this

CO₂ react to form sodium carbonate, thus $3\text{NaOH} + \text{CO}_2 = \text{Na}_2\text{CO}_3 + \text{NaOH} + \text{H}_2\text{O}$. This sodium carbonate reaches the anolyte by diffusion through the diaphragm and there reacts with the lead acetate to form white lead.



The white lead precipitated under these conditions does not adhere to the anode but settles to the bottom of the cell. From here it is drawn off by a pump (9) into a tank (8), where the settling is complete, the white lead being removed through a valve (11). Electrolytic white lead low in carbonate is amorphous, while that high in carbonate is crystalline. The proper control, by means of the bypass (18) and valve (17) of the amount of carbon dioxide supplied the catholyte, determines the quality of the product. (1,308,948; assigned to E. A. Sperry, July 8, 1919.)

Caustic Soda From Black Liquor Ash.—DANIEL S. MCAFEE of New York City has combined the leaching and causticizing process as practiced in soda pulp paper mills. The spent liquor from the blown digestors is concentrated in vacuum evaporators to about 36 deg. B.—when its fuel value is sufficient to maintain combustion in a rotary kiln. The quenched cinder taken from the kiln contains from 70 to 85 per cent sodium carbonate and from 12 to 25 per cent carbon in a highly porous condition. Part of the soda used in each cycle is lost through adsorption on the cellulose pulp, in the finishing wash liquors and principally as sodium vapor in the black ash kiln. An amount of fresh soda ash



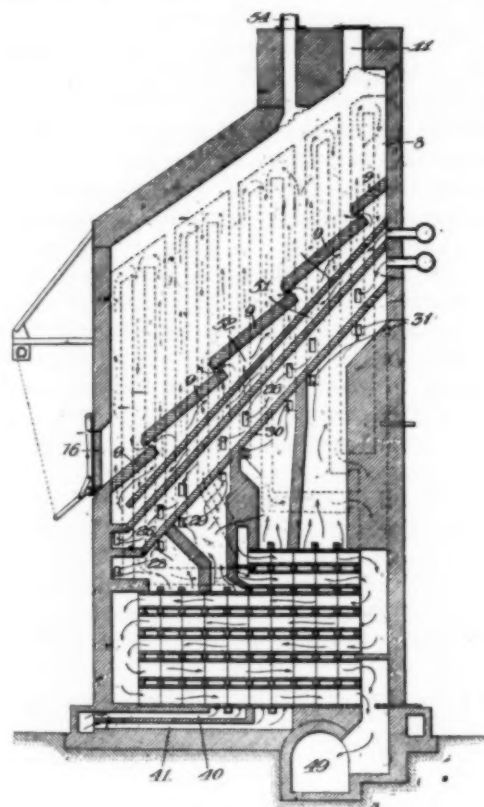
PROCESS OF OBTAINING CAUSTIC SODA FROM BLACK LIQUOR ASH

sufficient to balance this loss is continuously added to the system together with the black ash and burned lime. The aggregate is pulverized and mixed in a tube mill with water and flowed into agitator tanks in which the causticizing is completed. The caustic soda liquor is removed from the lime carbon slime in Dorr thickeners. A diagram illustrating the operation of the process is given so that the compactness of the installation can be noted, which is an essential feature if the process is to be put in the average soda pulp plant. (1,308,184; assigned to the Dorr Co.; July 1, 1919.)

Separation of Molybdenum Ores.—T. R. FORLAND of Hangesund, Norway, patents a process for the separation of molybdenum from its sulphide ores. A current of chlorine gas, at a temperature above 268 deg. C., is brought into contact with the dried and pulverized ore or concentrate. Molybdenum chloride distills

over and is separated from free sulphur and any metallic chloride having a lower boiling point by fractional condensation. In case the ore contains metals whose chlorides have a higher boiling point than that of molybdenum, the temperature may be so controlled that these chlorides remain in the tailings, from which they are recovered by leaching. (1,308,735; July 1, 1919.)

Shale Retort.—C. O. HOOVER of Denver, Colo., patents the retort illustrated, for treating material containing condensable hydrocarbons. It consists of a series of narrow, vertical retorts (8), charged through



SHALE RETORT

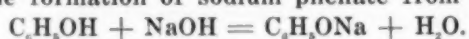
11 and drawn at door 16. Volatile matter is withdrawn through 54 and passed through a series of condensers and a portion of the fixed gases returned for heating purposes. Another portion re-enters the retort itself, being preheated by passing chambers 51 and 52, thence working up into the charge between shelves 9 forming the floor of the retort. Such circulation not only equalizes the heat of the charge, but carries away evolved hydrocarbons before they break down. Arrows indicate the course of heating gases, entering the vertical flues through nostrils 26, there burning, thence passing down through the horizontal regenerating flues to waste tunnel 49. Air for combustion enters 40 and 41, works its way up around the horizontal regenerating flues, there being preheated, and is introduced to the vertical flues for combustion through nostrils 28, 29, 30 and 31. (1,305,109; May 27, 1919.)

Electrode.—E. A. C. SMITH of New York City describes an anode for use in the electrolytic deposition of metals such as copper from an acid solution. The body of the anode is of silicon iron containing about 15 per cent silicon. Copper leads are cast into the anode and the melting of the copper is prevented by leaving the copper lead in contact with a chill plate at the bottom of the mold. (1,311,096; July 22, 1919.)

Synopsis of Recent Chemical and Metallurgical Literature

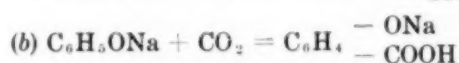
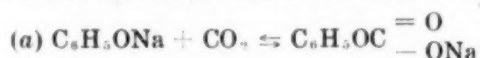
Manufacture of Synthetic Salicylic Acid.—An extremely practical description of the modern process for the manufacture of salicylic acid was given in a recent issue of the *Chemical Age*¹ by E. P. Wightman and George Robinson. Out of the many possible methods of synthesis, only two have achieved commercial success—the Kolbe and the Schmitt processes, which involve the following reactions:

1. The formation of sodium phenate from phenol:



2. The phenate combines with carbon dioxide to give either

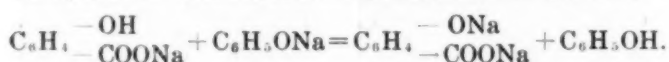
- (a) sodium phenyl carbonate or
- (b) o-carboxylsodium phenolate or some of both:



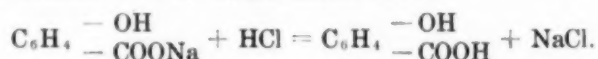
3. The transformation of either of these into their isomer, sodium salicylate:



4. Any unchanged or reformed sodium phenolate (by reversal of reaction 2a) combines with the sodium salicylate to form disodium salicylate and phenol:



5. The free acid is precipitated from a solution of its sodium salt by hydrochloric acid:



The Kolbe synthesis requires a high temperature but works under atmospheric pressure. The disadvantages are that, under these conditions, reaction 2a goes from right to left and thus a large percentage of phenol remains unconverted (see equation 4). However, at least one large plant in this country is employing it with apparent success.

In the Schmitt process, the reversal of reaction 2a is prevented by increasing the active mass of carbon dioxide present. Pure sodium phenate is first prepared by melting an amount of U.S.P. phenol equivalent to 236 lb. 100 per cent phenol and stirring it into a hot solution of 100 lb. of 100 per cent caustic soda in 19 gal. of water contained in a jacketed autoclave, which must be made of bronze if the chemical method of purification (see below) is to be used. The phenate solution is evaporated under diminished pressure and finally dried to a fine powder, which must be perfectly dry, as the slightest trace of moisture will vitiate the results. After cooling, carbon dioxide is allowed to enter until the inside has attained atmospheric pressure and then at such a rate that a pressure of 10 lb. is reached within an hour. The temperature must be kept below 50 deg. C., since the

reaction is exothermic. During the next hour the gas pressure is raised slowly to 100-110 lb. and the temperature to 130 deg. C. As soon as all the phenylcarbonate has been isomerized to salicylate, the partial (dissociation) pressure due to the phenylcarbonate disappears and the gage pressure registers a temporary drop. (The dissociation pressure of sodium salicylate is only 143 mm. at 220 deg. C., while that of sodium phenylcarbonate is greater than one atmosphere at 85 deg. C.) The gas pressure is cut off and, after heating for another hour, the mass is cooled and dissolved in hot water. The yield of crude sodium salicylate is from 98 to 99 per cent of theoretical.

There are two general methods of purification—the steam distillation, or physical, method and the precipitation, or chemical, method. For the first method, the free acid is precipitated from a hot solution of the crude sodium salt by adding 1 to 1 sulphuric acid, cooling and filtering. The acid precipitated cold is amorphous, is very difficult to centrifuge and holds water tenaciously. The acid is melted in an oil-heated still and distilled at a temperature of about 175 deg. C. by means of superheated steam. The condenser must be made of some non-ferrous alloy.

The product is a fluffy, white, needle-like crystalline acid with a faint odor of phenol (due to slight decomposition during distillation), which may be removed by washing with cold water in a centrifuge.

The chemical method employs stannous chloride as follows: In the purification kettle (preferably glass enameled, steam jacketed and provided with a stirrer) some of the solution of crude sodium salicylate is made faintly acid with C.P. sulphuric acid, heated to 90-100 deg. C. and treated in succession with:

- (a) A solution of stannous chloride containing 2 to 3 per cent of tin salt by weight of the salicylate.

- (b) Flake or powdered aluminum 1 to 1½ per cent. (This may or may not be used.)

- (c) Acid-washed bone or blood charcoal (free from phosphates and iron); about 4 per cent. .

- (d) Concentrated sodium carbonate solution until neutral to litmus. If the solution remains either acid or alkaline, tin or aluminum or both may be carried through to the final product.

Filter hot through a filter press into a precipitating tank, which contains 1 to 5 sulphuric acid. Cool, centrifuge and wash in centrifuge with cold water until free from soluble salts. During the whole of the purification process, the solution must not come in contact with iron. The yield is 94 to 95 per cent theoretical, whereas the steam distillation rarely yields more than 90 per cent. The acid is dried on shelves in a room through which warm dry air at not over 60 deg. C. is drawn.

EDITOR'S NOTE.—The importance of salicylic acid as a dyestuff and medicinal intermediate is shown by the fact that 3,270,462 lb. of the U.S.P. grade, valued at \$2,706,171, was produced by 13 firms in 1918. During the same period, eleven firms produced 1,395,630 lb. of the technical grade, valued at \$799,337. The most important derivatives of salicylic acid used medicinally are: the sodium salt, acetyl salicylic acid (aspirin), phenyl salicylate (salol) and methyl salicylate. As a dyestuff intermediate, salicylic acid is used in the manufacture of alizarine yellow G (m-nitrobenzene-azo-salicylic acid) and other dyes which were used in large quantities during the war for the production of khaki.

¹*Chemical Age*, vol. 1, July 25, 1919, p. 79.

Electric Production of Carbon-Free Alloys

By E. F. NORTHRUP

A METHOD is now available and commercially perfected whereby any metal or alloy in granular form, in small broken pieces or in solid masses can be melted absolutely free from carbon and all other chemical contamination, provided this metal fuses at a temperature under the fusion temperature of pure zirconia.

The apparatus needed is a source of high-frequency current of 10,000 cycles per second or over, and a special type of induction furnace. This source of high-frequency current, in power units from 1 up to 100 kw., has been developed in the oscillatory current system which

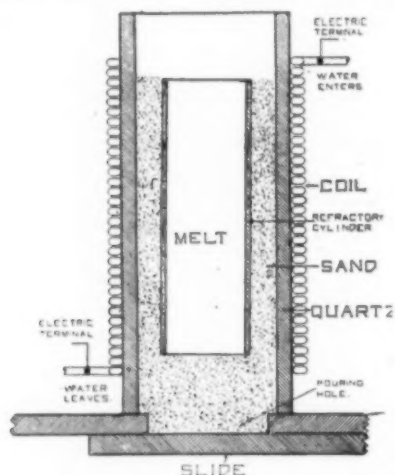


FIG. 1. CROSS-SECTION VIEW OF SCHEME OF FURNACE

forms the major portion of the Northrup-Ajax high-frequency induction furnace. The complete theory of this method of electric heating by high-frequency induction has been given in a paper by the writer, presented at the April 3 to 5, 1919, meeting of the American Electrochemical Society.

The special type of induction furnace required for obtaining carbon-free melts is the subject of this brief sketch and is indicated in one of its forms diagrammatically in Fig. 1. This diagram is almost self-explanatory. The tremendous concentration of energy produced by inductive action in a comparatively small volume makes it necessary to maintain the inductor coil cool by artificial means. To accomplish this cooling in a simple and effective manner, the material used for winding the inductor coil is a thin-walled, flattened copper tubing. It is flattened and wound edgewise to obtain the maximum possible number of turns to the inch. A small flow of water through this tubular coil maintains it always at the temperature of the tap water used.

The melt, which is located within the inductor coil and which may be only $\frac{1}{2}$ to 1 in. less in diameter than the inside diameter of the coil, may be raised to a temperature of 2500 or 2800 deg. C., the coil remaining under 20 deg. C.

The procedure in making a melt of any electrically conducting material, such as electrolytic iron or nickel with which other metals are to be alloyed, is as follows:

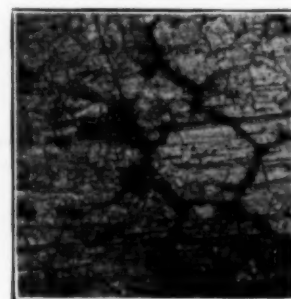
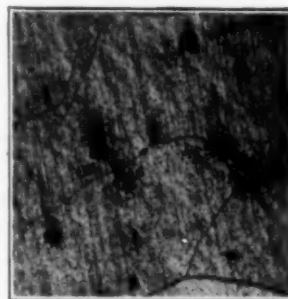
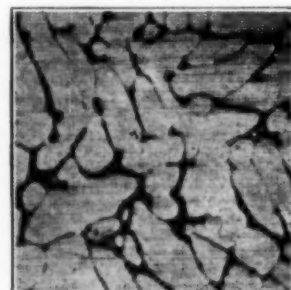
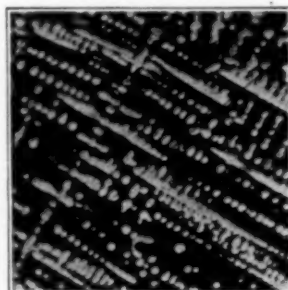
A thin-walled crucible or open cylinder of fire-clay, magnesia, zirconia or like material is formed. This is located centrally in the inductor coil and the space outside and under this cylinder is filled in with fine

alumina, silica or zirconia sand. The metal or component parts of the alloy to be produced is broken into small pieces, preferably about the size of walnuts, and packed in the thin-walled cylinder. When the high-frequency current is passed through the inductor coil rapid heating begins at once. This heating is due solely to the enormously large eddy currents which flow in the small conducting masses of the product being heated.

Melting of pure iron in lots of 2 to 5 lb. begins in from 10 to 20 min. and high super-heat is reached in 25 min. When the mass has become completely molten, more material may be dropped in. The melted mass does not leak even though the thin-walled container cracks and breaks, for this is imbedded in a mass of sand which makes a natural metal-tight pocket. As soon as the mass becomes molten a very useful and interesting phenomenon is noted. The surface of the molten mass becomes much agitated and the central region of this surface is raised a considerable fraction of an inch above its circumferential region. The metal or alloy is in fact subjected to a vigorous stirring action. Metal flows vertically upward in the axial region and downward in the circumferential region, and thus an alloy becomes automatically most thoroughly mixed. This stirring action is not a thermal phenomenon, but is caused solely by the action of the electromagnetic forces. Its importance is easily recognized when a perfect mix of the constituents of the alloy is desired.

The following results are readily obtained in this method of heating:

1. All conducting materials may be raised to 2500 or 2800 deg. C. or to their vaporization temperature in



MICROGRAPHS OF CARBON-FREE ALLOYS OF ELECTROLYTIC IRON. $\times 75$

75% Cu = 25% Fe 25% Cu = 75% Fe
95% Fe = 5% Mo 92% Fe = 8% Cu

an oxidizing atmosphere. Platinum is easily melted in this way.

2. By placing the inductor coil on the outside of a quartz tube which is closed at both top and bottom, melts may be made in any atmosphere or in vacuum.

3. In the open type of furnace, the molten metal can be drawn off from the bottom into a mold.

4. The quantity of metal, Ni, Fe, Pt, etc., which

can be handled at a single melt is determined wholly by the size of the furnace employed and the power available. An inductor coil of 40 turns, 6 in. long by 3½ in. inside diameter, supplied with 10 to 20 kw., will melt 4 lb. of electrolytic nickel or iron at a charge in from 20 to 30 min. Larger furnaces supplied with larger power will handle larger quantities.

Palmer Physical Laboratory,
Princeton, N. J.

A New Compensated Heatmeter

By CHARLES P. FREY,

Chief Engineer, Brown Instrument Co., Philadelphia, Pa.

UNTIL comparatively recently the determination of furnace and kiln temperatures by means of thermocouples was attended with complications and difficulties which made practical men impatient and in some instances doubtful in regard to the intrinsic value and reliability of the method. Technical men, however, have realized from the beginning that, within certain temperature limitations, the results obtained by the use of thermocouples were not only accurate, but could be made "direct reading," provided the thermocouple be connected with a galvanometer which would indicate the actual value of the e.m.f. obtained by heating.

On first consideration, this problem did not seem difficult of solution, since it is an established fact that the e.m.f. or voltage of a thermocouple bears a direct relation to the difference in temperature between its hot and cold ends. It is also true that the movable coil of a millivoltmeter will be deflected to an extent which is directly proportional to the e.m.f. of the thermocouple. Therefore it would seem the simplest operation imaginable to connect the thermocouple and the instrument by insulated conductors, figure the scale in temperature values, and regard the problem as solved.

Unfortunately, however, we have also to contend with factors which cannot be ignored if accurate results are required; namely, line resistance, thermocouple resistance and the resistance of the indicator itself; because, to be precise, a direct current millivoltmeter actually is not a millivoltmeter at all, except in name, but is a milliammeter or current indicator. All instruments of the d'Arsonval type depend primarily upon current for their operation, and the extent of the deflection obtained with any given current is established by the intensity of the magnetic field, the controlling force of the springs and the number of convolutions or ampere turns in the movable coil, and not by a remote e.m.f. Therefore, if the conductors which carry the current from the source of e.m.f. to the terminals of the instrument do not have a negligible resistance, then, in accordance with Ohm's law, there will be an appreciable fall of potential along the line, with the result that the movable system will receive a diminished current, and therefore be low in its readings. To reduce such errors to a minimum, it is desirable that the instrument resistance be as high as possible, so that the line and thermocouple resistance may be proportionately insignificant.

For instance, when this is not the case: If the resistance of the millivoltmeter *M* (Fig. 1) is 300 ohms and the resistance of the line *A* and thermocouple *C* is 3 ohms, the current through the circuit will be reduced practically 3 parts in 300, or 1 per cent, and the instrument indications will be 1 per cent low. Figured in degrees Fahrenheit, this would mean an error of ap-

proximately 14 deg. in 1400 deg. F., if a thermocouple were used.

The advantage of high-resistance instruments, therefore, becomes evident. For instance if the pyrometer has a resistance of 600 instead of 300 ohms, and the line resistance remains the same, an error of 3 parts in 600 will result, or only ½ of 1 per cent instead of 1 per cent, or about 7 deg. F. in 1400 deg. F.

Until within the last five years it was customary to use a so-called low-resistance pyrometer to measure the current from the thermocouple. These instruments had from 2 to 5 ohms internal resistance and were naturally materially affected by the external resistance of the thermocouple and leads. In the past few years high resistance pyrometers have been almost universally adopted. These instruments have an internal resistance of usually from 300 to 1200 ohms. The higher the resistance, naturally the less the effect on the readings due to variations in line resistance. But with increase in internal resistance, something had to be sacrificed, and usually control or torque is weakened. In consequence, the instrument is not as substantial or dead beat, and, due to the use of lighter springs, is more apt to be affected by spring fatigue.

It has been found by trial that an instrument of medium resistance (about 300 ohms) can be produced in a satisfactory and substantial form, but an instrument of this class is necessarily affected in its indications when leads of considerable length are employed. Material variations in the length of thermocouples are also a source of error, as well as the introduction of compensating leads. When compensating leads are employed, as well as long wires, in connecting the thermocouple with the instrument, it is a common practice to reduce the resistance of the instrument in order to offset the effects of line resistance. This is at best a method of doubtful value, since it interferes with checking the scale by comparison with a standard, and does not compensate for changes in the resistance of the line or thermocouple, due to variations in temperature.

Various devices and attachments have been made for use in connection with indicating and recording millivoltmeters and pyrometers, by means of which the instruments will remain direct reading, and at the same time be compensated for external or line resistance. Inventions of this class range all the way from a simple step rheostat connected in series with the "dead" resistor of the instrument to the elaborate and complicated apparatus employing the substitution and deflection methods, the potential of the thermocouple being first balanced against another potential derived from a dry cell; and after an intermediate operation and an inter-comparison of deflections, the effect of line resistance is finally balanced out by a rheostat, and direct deflections are obtained from the thermocouple current.¹

It remained for two physicists² of the Bureau of Standards, Washington, to offer an invention of theirs, which, incorporated in a Brown pyrometer, eliminates the effect of line and thermocouple resistance by means of an operation which is so simple that anybody can use the instrument and obtain accurate results. This improved heatmeter will unquestionably appeal to the practical man who wants results and does not care especially how the instrument functions, provided its indications can be relied upon.

¹The Brown precision heatmeter.

²Paul D. Foote and T. R. Harrison.

In testing with this apparatus all that is necessary is to connect the thermocouple with the instrument binding posts in the usual manner, press a button, turn a knob and take a reading, which will be the correct e.m.f. of the thermocouple at its hot end, even if the line is miles in length. In fact, the line may have as much as 15 ohms resistance.

For those who would like to understand the fundamental principle of the Harrison-Foote invention, and at the same time prefer a simple demonstration, the following explanation should be of interest, especially since it reduces the method to its most elemental form by substituting an ammeter in place of a pyrometer, and using cells instead of a thermocouple.

If A (Fig. 2) is an ammeter of negligible resistance in series with three resistors of 11, 8 and 11 ohms respectively, and an e.m.f. of 6 volts is impressed by a battery, also of negligible resistance, it is evident that the resistance in circuit will be $11 + 8 + 11 = 30$ ohms, and by Ohm's law ($C = E \div R$) the current

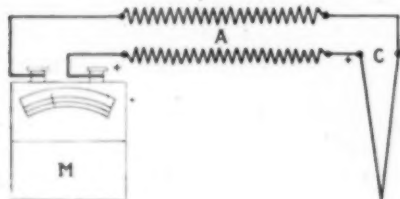


Fig. 1

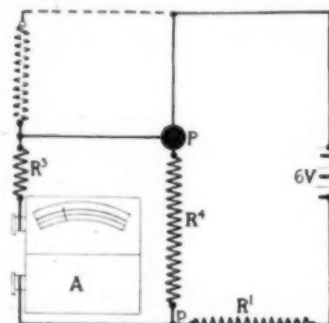


Fig. 3

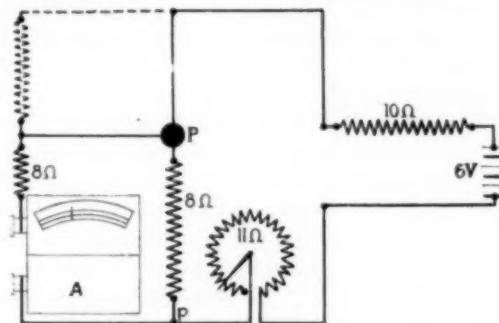


Fig. 5

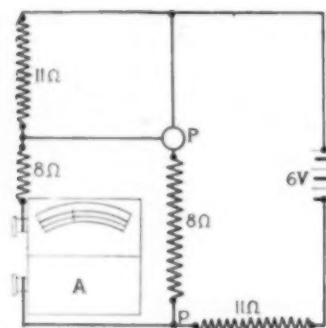


Fig. 2

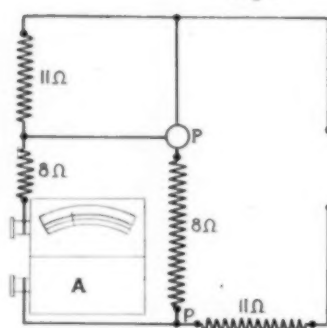


Fig. 4

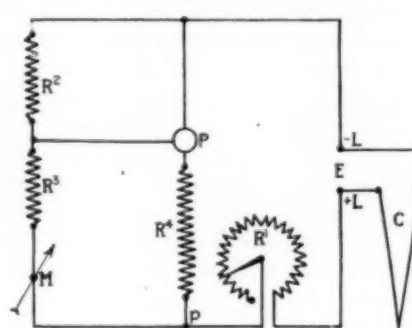


Fig. 6

throughout the circuit will be $6 \div 30 = 0.2$ amp. and the ammeter will indicate accordingly.

If now (Fig. 3) a plug is inserted in P, the resistor R^3 will be short-circuited. By the same operation, the resistor R^1 , which also has a resistance of 8 ohms, will shunt or "by-pass" the ammeter, thereby robbing it of part of its current. In other words, the current splits when it reaches the plug, part of it going through R^3 and the ammeter, and the remainder through R^1 , reuniting at p and passing through R^1 back to the battery.

The total current in this case will, of course, depend upon the total resistance in circuit. Since R^3 is cut out, the resistance will be

$R^1 (= 11 \text{ ohms}) + R^3 + R^4$ (R^3 and R^4 are in parallel).

By the law of divided circuits, the resistance of R^3 and R^4 will be their product divided by their sum, or

$$(8 \times 8) \div (8 + 8) = 4 \text{ ohms}$$

the total resistance being 15 ohms and the current being $6 \div 15 = 0.4$ amp., twice the current flowing in Fig. 2.

But it is obvious that, since R^3 and R^4 are alike in resistance, the current in splitting at P will divide evenly, half of it passing through the ammeter. Therefore the ammeter will indicate only one-half of the total current, or 0.2 amp., the same as in Fig. 2. Hence, under these conditions the deflection of the ammeter will not be changed whether the plug is in or out. If, however, 10 ohms of line resistance is added to the circuit (see Fig. 4) the current with plug out will be $6 \div (11 + 8 + 11 + 10) = 0.15$ ampere.

With plug in, R^3 is cut out as before, and the total resistance will be

$10 + 11 + (8 \times 8) \div (8 + 8) = 25$ ohms, and the current will be

$$6 \div 25 = 0.24 \text{ ampere.}$$

Of this current, one-half, or 0.12 amp., will pass through the ammeter. Its deflection will hence be less than in Fig. 2 when the plug is inserted, and the ammeter pointer will move down scale. To remedy this, let R^1 be in the form of a rheostat (Fig. 5). Then if the

resistance of this rheostat is reduced an amount equivalent to the 10 ohms of line resistance, the conditions prevailing in Figs. 2 and 3 will be re-established, the line resistance will be compensated for, and the pointer will again indicate 0.2 amp., with plug in or out; all of which is very simple and self-evident after it has been demonstrated and explained.

In the actual construction of the instrument for technical and practical use, the movable system consists of a highly sensitive copper or aluminum wire coil suitably mounted in an intense magnetic field. In place of the plug P, a three-way press button is used. The shunt R^4 need not, of course, have a resistance equal to that of R^3 ; in fact it is preferable so to proportion it that the current through the circuit as a whole may be increased eight to ten times. The deviation of the pointer from normal will hence be large for even a very slight change in line resistance, permitting easy adjustment.

In practice the rheostat R^1 has a resistance of 15 ohms, subdivided into steps of approximately 0.05 ohm.

so that the position of the pointer may be regulated with absolute exactness. In this connection it is in order to call attention to the fact that, while it is, of course, desirable to know what the range of the rheostat is, it is not at all necessary to know or attempt to determine what the line resistance may be. The rheostat is normally set at zero and, in testing for line resistance, is given a clockwise motion. In an experimental model the following proportions were adopted with excellent results (see Fig. 6).

Total resistance for 40 millivolts, 290 ohms.
Current without plug, 0.000138 ampere.
Current with plug, 0.00106 ampere.
Resistance of shunt, 26.25 ohms.
Movable system, 53.3 ohms, copper wire coil.
Rheostat, 15 ohms.

The temperature coefficient of the instrument was ± 0.000365 deg. F. It is, of course, possible to construct these heatmeters with much higher resistances to meet special requirements, but excessively high values in ohms per millivolt are not factors of first importance in this type of pyrometer.

As already stated the shunt R' need not have a resistance equal to that of R^2 , which is proved by the appended demonstration in which the following notations are employed:

- R^1 = Maximum or "zero" position of rheostat.
- R^2 = Resistance of ballast coil.
- R^3 = Resistance of swamping coil and movable system in series.
- R^4 = Resistance of shunt.
- RL = Line resistance.
- Rt = Sum of line resistance and resistance of rheostat when it is in any given position.
- I = Current flowing through movable system.
- E = e.m.f. of thermocouple at any given temperature.

In adjusting the instrument circuits at our laboratory, the resistors are so proportioned that

$$R^1 \div R^2 = R^4 \div R^3$$

The scale is graduated so that the instrument will give correct readings when

$$Rt = R^1$$

Assuming the instrument to be connected as in Fig. 6, and with plug out, then

$$I = E \div (R^2 + R^3 + Rt)$$

When the plug is in, the total current becomes

$$E \div [(R^2 \times R^4) \div (R^2 + R^4) + Rt]$$

Since the resistance of a divided circuit (the swamping coil and movable system in shunt with R^4) is the product of the individual resistances divided by their sum, this current will proportion itself in the two arms of the divided circuit in inverse ratio to their resistances. Therefore

$$I = \left[R^4 \div (R^2 + R^4) \right] \left[E \div \left(\frac{R^2 \times R^4}{R^2 + R^4} + Rt \right) \right]$$

Or, simplifying

$$I = R^4 E \div (R^2 \times R^4 + R^2 \times Rt + Rt \times R^4) = E \div \left(R^2 + \frac{R^3}{R^4} \times Rt + Rt \right)$$

The rheostat is adjusted so that this current equals the current obtained with plug out. Then

$$E \div \left(R^2 + \frac{R^3}{R^4} \times Rt + Rt \right) = E \div (R^2 + R^3 + Rt)$$

Therefore: $R^2 \div R^4 \times Rt = R^3$

$$\text{or, } Rt = R^3 \times R^4 \div R^2 = R^1$$

Since Rt now equals R^1 , the instrument will give correct readings.

It is in order to add that, while an experimental model has been referred to for data, the development of these instruments has long since passed the experimental stage, and, in practical form, the improved Brown heat-

meters, incorporating the Harrison-Foote method, have all of the following advantages:

They are direct reading throughout their entire scale range.

They require no dry cells or standard cells.

They are independent of line or thermocouple resistance.

They have a negligible temperature coefficient.



The operation of these instruments is simplicity itself. It cannot be questioned that such an instrument is a radical improvement on any of the various forms of electric pyrometers heretofore available and represents another noteworthy advance in pyrometry.

Production of Algin

Chemists throughout the country will be interested to know that the Hercules Powder Co. is devoting a good deal of attention to the extraction of algin from kelp. Algin is a substance whose properties are widely known, being a vegetable gum of extremely high viscosity. Its manufacture and use are on a firm footing in Europe, but so far the industry has never become well established in this country, largely, it is thought, because of difficulties in the way of securing a uniform supply of fresh kelp at a reasonable cost. The experience gained by the Hercules Powder Co. in harvesting kelp for the manufacture of war materials has overcome these difficulties as far as this organization is concerned.

There is a wide field of possible usefulness for algin. Algin compounds in general give an exceedingly vis-

cous solution, and for that reason their application as a sizing for textiles and paper, as a thickener for printing colors and as a proofing for interior walls and ceilings is at once apparent. The sodium compound of algin is soluble in water, a 5 per cent solution thereof being so viscous that it can hardly be poured from a vessel. The compounds of the heavy metals with algin are insoluble in water, some of them being soluble in ammonia, which solvent is used in their application as a waterproofing material in textiles.

Book Reviews

AMERICAN METHODS IN FOREIGN TRADE, A GUIDE TO EXPORT SELLING. By George C. Vedder. ix + 204 pages. New York: McGraw-Hill Book Co., Inc.

The ability of a country to export a manufactured article or a product depends upon its quantity production in quantity more than sufficient for home consumption. The demand for any article is in the last analysis a function of its quality. The producer who gives most for value received acquires a business good-will which is the foundation upon which success is built. In competing in foreign markets the demand is in proportion to quality. Business success at home predicates success abroad, but there is the barrier of an international boundary and all that that connotes. The manufacturer who finds himself in the position to produce in larger quantities and requiring an extended market abroad will find in Mr. Vedder's book sound advice and authentic information gained through many years' intimate acquaintance with successful exporters. This book should serve as a guide in establishing a sound export selling policy.

Increased foreign trade is responsible for our more intimate association with other nations. It makes necessary certain phases of our Government's foreign policy. The chapters on the nationalization of foreign trade, foreign credits, American banks abroad, the merchant marine, reciprocity in foreign trade and the tariff are of interest to more general readers. They contain an analysis of the underlying conditions and the various factors which will broaden the reader's understanding in these matters.

L. W. CHAPMAN.

Personal

MR. ROBERT FOGELSON, formerly with the research division, Chemical Warfare Service, has accepted a position with the Newport Chemical Works, Inc., Carrollville, Wis.

DR. ELLIS I. FULMER, formerly of the faculty of arts, department of chemistry, University of Toronto, has accepted a position as assistant professor of chemistry, Iowa State University, Ames, Iowa.

MR. REGINALD E. HORE has resigned the editorship of the *Canadian Mining Journal* and is succeeded by MR. F. W. GRAY, formerly associate editor.

COL. W. R. LANG has relinquished his duties in Military District No. 2 to resume his chair as head of the department of chemistry, University of Toronto.

MR. HAROLD N. LAWRIE, chairman of the Board of the Oregon Bureau of Mines and Geology, has accepted the active chairmanship of the Division of Precious and Rare Metals in the American Mining Congress.

MR. DORSEY A. LYON has been made chief metallurgist of the Bureau of Mines, vice Dr. Cottrell, in conjunction with the position of supervisor of stations.

DR. VAN H. MANNING of the U. S. Bureau of Mines was in San Francisco Aug. 15 to 18 on a tour of inspection of the Bureau's experiment stations.

DR. ARTHUR C. NEISH, who for the past twenty years has been on the staff of the department of chemistry, Columbia University, New York City, has accepted the chair of chemistry at Queen's University, Kingston, Ont., and will undertake his new duties with the opening of the university in October.

MR. ROBERT F. REED has resigned his position as superintendent of the Norwood, Ohio, dye plant of the Ault & Wiborg Co. to accept a position in the Deepwater Point, N. J., dye plant of E. I. du Pont de Nemours & Co.

DR. R. F. RUTTAN, head of the chemical department of McGill University, Montreal, was in England during July, where he attended the International Convention of Chemical Societies in London, July 15, as representative of the Canadian Society of Chemical Industry.

MR. JEROME D. STEIN, formerly control supervisor of the nitrate division, U. S. Nitrate Plant No. 2, Muscle Shoals, Ala., has accepted a position with the Gordon Dryer Corporation.

MR. JACK A. THOMAS has resigned his position as department manager of the chlorinated products section of the Rollin Chemical Co. because of ill health.

Current Market Reports

The Non-Ferrous Metal Market

Monday, Aug. 25.—During the past two weeks, only minor fluctuations took place. Prices in general have assumed a normal bearing with regard to production costs and consumption offers.

Aluminum:—Transactions are mainly by direct contract. The open market continues quiet; 98-99 per cent ingots are quoted at 33c. per lb. Scrap casting, 21 to 24c.; sheet scrap, 22½-25c., and clipping, 24 to 27c.

Antimony:—The market is easy; spot wholesale is quoted at 8½c. Job lots, 9c. lb.

Copper:—The market is firm with present quotations at 23½c. lb. and 24c. for the last quarter of the year.

Copper sheets, hot-rolled.....	lb.	33.50 —	.....
Copper sheets, cold rolled.....	lb.	35.00 —	.....
Copper bottoms.....	lb.	41.50 —	.....
Copper rods.....	lb.	24.00 —	.....
Copper wire.....	lb.	25.00 —	.....
High brass wire and sheets.....	lb.	27.75 —	.....
High brass rods.....	lb.	26.75 —	.....
Low brass wire and sheets.....	lb.	30.50 —	.....
Low brass rods.....	lb.	31.25 —	.....
Brazed brass tubing.....	lb.	39.00 —	.....
Brazed bronze tubing.....	lb.	44.25 —	.....
Seamless copper tubing.....	lb.	37.50 —	.....
Seamless bronze tubing.....	lb.	40.00 —	.....
Seamless brass tubing.....	lb.	36.00 —	.....
Scrap, heavy machinery comp.....		17 —	18
Scrap, heavy and wire.....		17 —	18
Scrap, light and bottoms.....		15 —	16
Scrap, heavy, cut and crucible.....		18½ —	19½
Scrap brass, heavy.....		10 —	11
Scrap brass, casting.....		12 —	13
Scrap brass, light.....		9 —	10
Scrap, No. 1 clean brass turnings.....		10 —	11
Scrap, No. 1 comp. turnings.....		15 —	16

Lead:—The dual lead market continues, the smaller producers quoting at a slight reduction, New York 5.8-6c. and East St. Louis 5.5-5.75c. lb. Cut sheet lead is bringing 9c.

Tin:—The freed tin market did not drop to as low a level as expected because large stocks are not available. Straits spots are at 58c. and electrolytic, 55½c.

Zinc:—Spot spelter has advanced to 7.9c. in New York and 7.5c. East St. Louis. Sheet zinc, 10c. lb.

OTHER METALS

Bismuth.....	lb.	\$2.95 —	.....
Cadmium.....	lb.	1.50 —	1.75
Cobalt.....	lb.	2.50 —	3.50
Magnesium.....	lb.	1.75 —	2.10
Mercury.....	75 lb.	101.00 —	.....
Nickel.....	lb.	.41 —	.45
Iridium.....	oz.	175.00 —	.....
Palladium.....	oz.	115.00 —	120.00
Platinum.....	oz.	105.00 —	110.00
Silver.....	oz.	1.13½ —	.....

The Iron and Steel Market

The second half of August constituted a crucial period in iron and steel market history. Labor unrest became more and more manifest. Strikes were not infrequent. Some were settled with little difficulty, but many were not settled. A strong feeling was shown among manufacturers against granting demands of men, as demands had become unreasonable. In some instances plants were closed upon the initiative of the management, trouble being in sight. Where strikes were settled the settlements involved small or no concessions, and some strikes that were allowed to go their way could probably have been settled by granting small concessions. Apart and probably entirely dissociated from these sporadic strikes was the general effort of the American Federation of Labor to unionize the entire industry.

On Aug. 26 there was published a plain and strong statement by President Wilson to the effect that there would have to be a truce in the demands of labor, and calling upon every one to assent. It is too early, at this writing, to observe widespread effects from this enunciation of a policy calculated to stop the "endless chain" or "vicious circle" of alternating increases in cost of production and increase in commodity prices, but the effects will undoubtedly prove very important. A turning point is probably marked.

Just before this statement was made by the President there was nothing in sight but difficulties. There was a strong possibility that a strike would be called or that plants would be closed in anticipation of strikes.

LABOR TROUBLES DOMINATE MARKET

The iron and steel market was dominated by the prospects of labor troubles. Producers became very reserved in their selling policies and in most finished products withdrew from the market except as to orders from regular customers. The mills were moderately well sold, but certainly not oversold. They feared they would be unable to produce anything like full tonnages.

Buyers were likewise influenced by the labor situation and prospects. A few buyers were moved to curtail their purchases because they did not wish to buy material when the mill obligation to deliver was qualified by strike and other clauses. The majority of buyers were influenced to offer greater tonnages to mills. Specifications against contracts were heavy and new purchases were attempted. The occasional or chance buyer generally failed to secure acceptance of his proffered orders.

The labor unrest had another effect upon the market. It made it clear to all producers except a few whose mental attitude is not readily explained that it would be extremely unwise to attempt to advance any prices. In June the Steel Corporation had allowed it to become known that as a settled policy the corporation was opposed to price advances, this year at any rate, and that view eventually became general. With mills fairly well sold up price advances would not materially increase incomes for several months, while in all probability they would stimulate demands for increased wages. As there is no influence remotely tending toward the lowering of prices, the general price level could hardly be more effectively stabilized than it is at this time.

REAL CONSUMPTIVE DEMAND NOT KNOWN

An unfortunate feature of the stimulus given to demand by the fear that production would be reduced is that the market as it is seen does not necessarily reflect the real consumptive demand. It is not known that buyers are really in position to consume all the steel they have been clamoring for. It is to be noted on the other hand that as a rule steel demand is light during the two midsummer months, and particularly toward the latter part of August, when the advent of Autumn is so near at hand that there is an unusual disposition to postpone purchases. The two influences may have pulled in opposite directions, and the more settled labor conditions that may now be expected with a considerable degree of confidence may not have the effect of decreasing the pressure of any buyers for deliveries.

While prospects as to the production of iron and steel may be regarded as greatly improved by the strong call of the President for a truce in the matter of labor demands, the iron and steel industry still has a difficulty arising from labor conditions, that difficulty being that the consumption or employment of steel in construction work is discouraged by the high cost of erection due to high wages and indifferent performance of labor. Much construction work that investors have in mind is not coming to a head because prospects as to cost of the work are not sufficiently well defined. The monthly reports of the Bridge Builders' and Structural Society have shown steady improvement in the volume of fabricated steel contracts let, such lettings representing 24½ per cent of the fabricating capacity in April, 49 per cent in May, 65 per cent in June and 74 per cent in July, but it is not certain that August will be found to have shown much if any improvement, and to give this branch of the industry a proper start after the war there should have been lettings for a few months at far beyond the capacity.

AUGUST STEEL PRODUCTION ABOUT 80 PER CENT

Production of steel in August, in terms of ingots, was probably between 75 and 80 per cent of capacity, but even with various curtailments due to strikes, particularly of railroad shopmen, the average percentage of capacity that was in operation was well above 80 per cent. The productive units in employment did not yield their normal tonnages, partly on account of the weather and partly on account of labor efficiency being well below par at many if not at all plants.

As some men are to be loyed for the enemies they have made, the demand for iron and steel must be admired through its being as it is when the basis of demand is lacking in so many respects. It is remarkable that the industry can produce at more than 75 per cent of capacity when there is such a small quantity of steel passing into large construction jobs and when practically no steel at all is passing to the railroads. Just before the war ended the common appraisal was that since steel productive capacity had increased by 40 per cent since 1914 it would require the fullest co-operation of all lines of steel consumption, combined with a very large export demand, to produce requirements that would represent the productive capacity. The buyers absent from the market represent much more than the amount by which production falls short of capacity.

The Chemical Market

New York, August 26, 1919.

The usual seasonal lull has settled on the local market. Quiet is the word which characterizes conditions in vegetable oil, wax and naval stores circles. Dealers in the first two commodities, particularly, are taking it easy until September has run its length and active interest is once more resumed. In contrast, trading in heavy chemicals is fairly brisk, although not so satisfactory as two weeks ago, while business in coal-tar products was never better.

Export business is practically at a standstill, owing to the unfortunate status of foreign exchange. Quantities of merchandise are stored in New York undelivered because sellers would rather hold their goods than execute orders and suffer the heavy losses resulting from the disparity in exchange values.

HEAVY CHEMICALS

Interest in *sodium bichromate* has abated somewhat, bringing a slight reduction in price. The quotation at this writing ranges from 14c.-15c. per lb., while 15c.-16c. was a fair price two weeks ago. England, France, Denmark and Spain have been the foreign buyers of this product.

Potassium chlorate is receiving few sales at 18c.-19c. per lb. Recent arrivals of *Alsation potashes*, together with the rumor that Germany is soon to send a like shipment, has contributed to this slackness.

Since the last review a fairly strong demand for *bleaching powder* (calcium hypochlorite) has developed, with South America the leading buyer, although domestic textile mills have bought in fair volume.

That *glacial acetic acid* has been in strong request for South America, England and France, as well as for domestic use, is attested to by the fact that delivery on this acid is not to be obtained under three or four weeks at August 15 quotations.

Muriatic (hydrochloric) is the only other acid offering particular interest. Heavy demand from Cuban sugar interests with a large domestic call has led to the boosting of the price in some quarters from \$1-\$1.50 per cwt. to \$1.75-\$2 for carlot quantities.

Although there is some talk of raising the export price on *caustic soda*, which was placed at \$3.50 per cwt. f.a.s. less 5 per cent by the U. S. Alkali Export Association, offerings are still being made of \$3.30-\$3.40 per cwt. f.a.s.

Alcohol is one of the few items which has increased in market value in the past two weeks. The large quantities of ethyl alcohol being exported, the high cost of wood alcohol and a general scarcity of goods are the reasons advanced for the increase. Methyl (wood, 95 per cent pure) is quoted at \$1.30 per gal. in carlots, an advance of 10c.; pure methyl at \$1.60; denatured, 188 proof, at 52c., and 190 proof at 46c.-48c. per gal.

COAL TAR PRODUCTS

The entire line is booming. During last week, in particular, a heavy volume of business was transacted, the buying coming not alone from dyestuffs and textile manufacturers, but from all classes of trade, such as rubber, paint and polish manufacturers.

Demand is strongest for aniline oil, salicylic acid, aniline salts, dimethylaniline and paranitraniline, the first two being very scarce.

In the words of one manufacturer, "Consumers are begging for aniline oil, but everyone has sold out his supply, as he has that of salicylic acid."

Along with the more refined coal tar products, crudes are participating in the increased activity, with toluol and benzol making their importance felt by an increase in price. The new price of benzol, pure waterwhite, is 25c. per gal. in carlots, the less carlot price ranging from 26c.-29c.; the 90 per cent variety, 24c. in carlots; whereas 24c., 25c.-28c., and 23½c., respectively, were the previous quotations. From 24c. per gal. in tank cars, toluol has jumped to 26c.

OILS

As in almost everything else, the foreign exchange situation has checked foreign business. On the other hand, there seems to be a tendency on the part of dealers to give less attention to export trade. Since November, 1918, a million barrels of vegetable and animal oils (the entire surplus) have been shipped abroad, leaving just sufficient to meet the normal domestic demand. In view of this condition, prices are expected to remain unchanged for some time.

The linseed oil market is in a slightly easier position than it was two weeks ago. Demand is less urgent, with prices holding unchanged at \$2.22 per gal. in carlots.

NAVAL STORES

Having gone as low at \$1.63 per gal., in the last two weeks, spirits of turpentine has returned to \$1.75. Scarcity of spot supplies is bulling the market.

Although rosins have dropped, due to the low rate of exchange and decreased demand, the market during the past few days has stiffened and appears likely to hold firm at the new prices, according to which W.W. is bringing \$24.75-\$25.00 and E \$18.50, in comparison with \$24.75-\$25.50 and \$19-\$19.50, respectively.

Among the flotation oils, the present price on pine oil, steam distilled, varies from the last quotation of 95c. per gal. by 10c.

St. Louis, August 22, 1919.

The strong demand for *nitric acid* has provided the feature of the local heavy chemical market in trading of the last two weeks. Producers are somewhat at a loss to account for the sudden interest in this acid, but believe that manufacturers of nitroglycerine are taking the bulk of their output.

Continued heavy demand for 60 deg. sulphuric has resulted in a tax on the capacity of local producers. The price remains around \$12. Despite slackness in local steel manufacture, demand for 66 deg. sulphuric is improving, as it is also for the 98 deg. Failure of Kansas City producers to fill some contracts on the 66 deg. has thrown the burden on St. Louis producers. The price still holds at \$18 for carlots.

Demand is strong for *muriatic acid*, although some difficulties are being experienced in shipping. The 18 deg. is still selling at \$22 in tank car lots. *Sodium bisulphate* (niter cake) is in strong demand. As high as \$3 a ton (representing an advance of \$1) has been offered, but little is on the open market.

Nitric acid has broken records for demand in the last month. The activity is laid to the demands of the nitroglycerine manufacturers. The 40 deg. Baumé is selling at 10 and 10½c. per lb., 38 deg. at 9c. and 42 deg. at 11c., all unchanged from the last report.

Zinc chloride is slack and quiet. Demand has fallen off but the price is holding at 4c. on the open market, 3½c. on contract.

Zinc oxide is still strong and even bigger business is looked for in the fall by local producers. Prices remain at 8c. to 9c. per lb. in carload lots, and ½c. higher for smaller quantities.

Ammonium chrome alum is in extremely heavy demand. Within the last ninety days the price has gone from 13½c. to 16½c. per lb. All of it is being exported and is being used by foreign tanners.

Chicago, August 25, 1919.

An accurate summing up of trade conditions in Chicago during the past fortnight is contained in the phrase "no change," as compared with the preceding several weeks. There have been no price changes of note, no great activity in any particular line and no export business of unusual scope. This is undoubtedly due to the fact that prices are now on a fairly high level and a feeling that speculators have a hand in boosting the market to its present point, this being particularly the case in vegetable oils. No great activity can be anticipated until there is either a recession in prices or consumers become convinced that prices are on a firm basis. Present buying is based solely on actual current needs.

Heavy Chemicals—No changes of moment in any item are recorded. *Sodium bichromate*, after its rapid rise in July, is holding firm at about 15c. *Red and yellow potassium prussiate* are as yet very hard to get, 70c. and \$1.10, respectively, being asked for the small quantities available. Among the acids, previous quotations hold good. *Nitric* is holding firm at 10½c. for 40 deg. Baumé, despite a rather poor demand.

Coal-Tar Products—*Salicylic acid* at 43c. seems high, but the price stays firm. No change is noted in *benzol* or *phenol*, and with demand good the entire line seems to be fixed for some time to come on the existing price basis.

Vegetable Oils—In spite of rapid and violent fluctuations on the grain exchanges, corn oil, under good demand, remains at 21c. for spot delivery. Linseed is still quoted in one to four-barrel lots to consumers at \$2.48, with 25c. off for large quantities. This seems high, but the fact that the entire production of the crushers is absorbed by the trade as rapidly as offered renders any decline unlikely. The Archer-Daniels Co., in its Minneapolis plant, is said to be crushing 10,000 bu. of flax every day.

Flotation Oils, Naval Stores—The steady increase of prices in these lines continues. Turpentine is now \$1.75, 0.933 test pure steam-distilled pine oil \$1.00 to \$1.05 and destructively distilled pine oil 90c. to 95c. The larger dealers report their entire visible supply of oils sold up to Dec. 1, and that they are not only refusing quotations to new customers but are short-filling orders from old ones. The cause of this famine condition is scant production during the past season and heavy export orders. During the recent harbor strike in New Orleans, 35,000 bbl. of pine oil, intended for export, accumulated on the docks in a few days. Such a severe drain on our already short supply can only produce a serious condition.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, AUG. 26, 1919

	Carlots	Less Carlots
Acetic anhydride.....lb.		\$0.54 - \$0.60
Acetone.....lb.	\$0.13 - 0.14	.15 - .15
Acid, acetic, 28 per cent.....cwt.	2.50 - 3.00	3.00 - 3.25
Acetic, 56 per cent.....cwt.	5.50 - 6.00	6.00 - 6.50
Acetic, glacial, 99½ per cent, carboys.....cwt.	12.00 - 12.50	12.90 - 13.50
Boric, crystals.....lb.	.13 - .13½	.13 - .14
Boric, powder.....lb.	.13 - .13½	.13 - .14
Hydrochloric, (muriatic) tech. 20 deg.....cwt.	1.00 - 1.50	1.75 - 2.50
Hydrofluoric, 52 deg.....lb.	.10 - .11	.11 - .16
Lactic, 44 per cent. tech.....lb.	.11 - .14	.12 - .16
Lactic, 22 per cent. tech.....lb.	.05 - .06	.05 - .07
Molybdenic, C. P.....lb.		4.50 - 5.50
Nitric, 40 deg.....lb.	.06 - .06½	.07 - .08½
Nitric, 42 deg.....lb.	.07 - .07½	.08 - .09
Oxalic, crystals.....lb.	.23 - .25	.25 - .30
Phosphoric, Ortho, 50 per cent. solution.....lb.	.09 - .10	.10 - .14
Picric.....lb.	.30 - .40	.50 - .60
Pyrogallol, reacidified.....lb.		2.50 - 2.45
Sulphuric, 60 deg., tank cars.....ton	12.00 - 14.00	
Sulphuric, 60 deg., drums.....ton	17.00 -	22.00 -
Sulphuric, 60 deg., carboys.....ton	20.00 -	25.00 -
Sulphuric, 66 deg., tank cars.....ton	16.00 - 18.00	22.00 - 23.00
Sulphuric, 66 deg., drums.....ton	20.00 - 21.00	25.00 - 26.00
Sulphuric, 66 deg., carboys.....ton	25.00 -	30.00 - 40.00
Sulphuric, fuming, 20 per cent. (oleum) tank cars.....ton	22.00 -	27.00 -
Sulphuric, fuming, 20 per cent. (oleum) drums.....ton	25.00 -	32.00 -
Sulphuric, fuming, 20 per cent. (oleum) carboys.....ton	30.00 -	35.00 -
Tannic, U. S. P.....lb.		1.30 - 1.40
Tannic (tech.).....lb.		.42 - .55
Tartaric, crystals.....lb.		.84 - .86
Tungstic, per lb. of WO.....lb.		1.20 - 1.40
Alcohol, Ethyl.....gal.	4.00 -	4.85 -
Alcohol, Methyl.....gal.	1.30 -	1.33 - 1.38
Alcohol, denatured, 188 proof.....gal.	.52 -	.54 - .55
Alcohol, denatured, 190 proof.....gal.	.46 - .48	.50 - .51
Alum, ammonia lump.....lb.	.03½ - .04½	.04½ - .04½
Alum, potash lump.....lb.	.08 - .09	.08½ - .09½
Alum, chrome lump.....lb.	.15 - .16	.18 - .20
Aluminum sulphate, commercial.....lb.	.012 - .02	.02½ - .02½
Aluminum sulphate, iron free.....lb.	.02½ - .03	.03½ - .03½
Aqua ammonia, 26 deg., drums (750 lb.).....lb.	.07 -	.08 - .09
Ammonia, anhydrous, cylinders (100-150 lb.).....lb.		.30 - .35
Ammonium carbonate, powder.....lb.	.13 - .13½	.14 - .14½
Ammonium chloride, granular (white salamoniac).....lb.	.12½ - .13	.13½ - .14
Ammonium chloride, granular (gray salamoniac).....lb.	.12 - .12½	.13 - .13½
Ammonium nitrate.....lb.	.10 -	.11 - .12
Ammonium sulphate.....lb.	.05 -	.06 - .06
Amyl acetate.....gal.		3.75 - 3.80
Arsenic, oxide, lumps.....lb.		.09 - .09½
Arsenic, sulphide, powdered.....lb.		
Barium chloride.....ton	75.00 - 80.00	85.00 -
Barium dioxide (peroxide).....lb.	.22 -	.24 -
Barium nitrate.....lb.	.10 - .10½	.11 - .12
Barium sulphate (precip.) (blanc fixe).....lb.	.02½ - .03	.03½ - .04
Bleaching powder (see calcium hypochlorite).....lb.		
Blue Vitriol (see copper sulphate).....lb.		
Borax (see sodium borate).....lb.		
Brimstone (see sulphur, roll).....lb.		.65 - .75
Bromine.....lb.		.65 - .75
Calcium acetate.....cwt.	2.00 - 2.05	2.10 -
Calcium carbide.....lb.		.04 - .05
Calcium chloride, fused, lump.....ton	19.00 - 25.00	30.00 - 40.00
Calcium chloride, granulated.....lb.	.01½ - .01½	.02 - .02½
Calcium hypochlorite (bleaching powder).....cwt.	1.75 - 1.80	2.00 - 2.50
Calcium peroxide.....lb.		1.50 - 1.70
Calcium phosphate, monobasic.....lb.		.75 -
Calcium sulphate, precipitated.....lb.		.09 - .09½
Carbon bisulphide.....lb.	.05½ -	.06 - .06
Carbon tetrachloride, drums.....lb.	.11 -	.12 - .14
Carbonyl chloride (phosgene).....lb.		.75 -
Caustic potash (see potassium hydroxide).....lb.		
Caustic soda (see sodium hydroxide).....lb.		
Chlorine, gas, liquid-cylinders (100 lb.).....lb.	.05 - .05½	.08 -
Cobalt oxide.....lb.		1.60 - 1.65
Copperas (see iron sulphate).....lb.		
Copper carbonate, green precipitate.....lb.		.28 - .31
Copper cyanide.....lb.		.65 - .70
Copper sulphate, crystals.....lb.	.08½ - .08½	.09 - .09½
Cream of tartar (see potassium bitartrate).....lb.		
Epsom salt (see magnesium sulphate).....lb.		
Formaldehyde, 40 per cent.....lb.		.19 - .21
Glauber's salt (see sodium sulphate).....lb.		.19 - .21
Glycerine.....lb.		4.50 -
Iodine, resublimed.....lb.		.40 - .50
Iron oxide, red.....lb.		.03 - .20
Iron sulphate, (copperas).....cwt.	1.00 -	1.20 - 1.50
Lead acetate, normal.....lb.	.12½ - .14½	.14 - .14½
Lead arsenate (paste).....lb.	.13 - .17	.17 - .17
Lead nitrate, crystals.....lb.	.85 - .86	.85 - .86
Litharge.....lb.	.09½ - .10½	.10 - .10½
Lithium Carbonate.....lb.	1.50 -	.13 - .14½
Magnesium carbonate, technical.....lb.		.13 - .14½
Magnesium sulphate, U. S. P.....100 lb.	2.00 - 2.63	2.75 -
Magnesium sulphate, commercial.....100 lb.	1.75 -	2.00 - 2.50
Nickel salt, double.....lb.	.14 -	.15 -
Nickel salt, single.....lb.	.12 -	.15 - .16
Phosgene (see carbonyl chloride).....lb.		.65 - .70
Phosphorus, red.....lb.		.35 - .37
Potassium bichromate.....lb.	.25 - .28	.55 - .60
Potassium bitartrate (cream of tartar).....lb.		.49 - .50
Potassium bromide, granular.....lb.		.65 - .70
Potassium carbonate, U. S. P.....lb.	.60 -	.65 - .70
Potassium carbonate, crude.....lb.	.17 -	.20 - .24
Potassium chlorate, crystals.....lb.	.20 - .24	.25 - .30
Potassium cyanide, 98-99 per cent.....lb.	nominal	.35 - .40
Potassium hydroxide (caustic potash).....lb.	.30 - .32	3.55 - 3.60
Potassium iodide.....lb.		.21 - .21
Potassium nitrate.....lb.	.19 -	.55 - .65
Potassium permanganate.....lb.		.90 - 1.10
Potassium prussiate, red.....lb.		

	Carlots	Less Carlots
Potassium prussiate, yellow.....lb.		.50 - .60
Potassium sulphate.....ton	225.00 -	
Rochelle salts (see sodium potas. tartrate).....lb.		
Salmoniac (see ammonium chloride).....lb.		
Sal soda (see sodium carbonate).....lb.		
Salt cake (sodium sulphate).....ton	17.00 - 18.00	
Silver cyanide.....oz.		1.19 - .68½
Silver nitrate.....lb.		1.67½ - .68½
Soda ash, light.....100 lb.	1.85 - 1.90	2.00 -
Soda ash, dense.....100 lb.	2.25 -	2.50 -
Sodium acetate.....lb.	.06 - .07	.07 - .08
Sodium bicarbonate.....100 lb.	2.35 -	2.75 - 3.00
Sodium bichromate.....lb.	.14½ -	.15 - .16
Sodium bisulphate (nitre cake).....ton	3.00 - 8.00	10.00 -
Sodium bisulphite.....cwt.	1.80 - 1.90	2.00 - 2.10
Sodium borate (borax).....lb.	.07½ -	.08 - .08
Sodium carbonate (sal soda).....100 lb.	1.35 - 1.50	1.50 - 1.75
Sodium chlorate.....lb.	.15 -	.16 - .18½
Sodium cyanide.....lb.	.30 -	.31 - .34
Sodium fluoride (caustic soda).....100 lb.	2.75 -	2.90 - 3.50
Sodium hydroxide (caustic soda).....100 lb.	2.75 -	3.25 - 3.50
Sodium molybdate.....lb.	3.00 - 3.25	3.75 - 4.00
Sodium nitrate.....100 lb.	3.00 - 3.25	3.75 - 4.00
Sodium nitrite.....lb.	.09½ - .10	.10 - .13
Sodium peroxide, powdered.....lb.		.30 - .32
Sodium phosphate, dibasic.....lb.	.03½ - .04½	.04 - .05
Sodium potassium tartrate (Rochelle salts).....lb.		.43 - .45
Sodium prussiate, yellow.....lb.	.17½ - .18½	.19 - .20
Sodium silicate, solution (40 deg.).....lb.	.01½ - .02	.02 - .02½
Sodium silicate, solution (60 deg.).....lb.	.02½ -	.04 - .04½
Sodium sulphate, crystals (Glauber's salts) cwt.	1.05 - 1.35	1.50 - 2.00
Sodium sulphide, crystal, 60-62 per cent. (cone).....lb.		.05 - .06
Sodium sulphite, crystals.....lb.	.03½ -	.04 - .04
Strontium nitrate, crystals.....lb.	.25 -	.28 -
Sulphur chloride.....lb.	.05½ -	.06 -
Sulphur, crude.....ton	22.00 -	
Sulphur dioxide, liquid, cylinders.....lb.		.10 - .12
Sulphur (sublimed), flowers.....100 lb.	3.00 - 3.05	3.65 - 3.60
Sulphur, roll (brimstone).....100 lb.	2.70 - 3.00	3.65 -
Tin bichloride (stannous).....lb.	.48 -	.49 - .50
Tin oxide.....lb.		.60 - .60
Zinc carbonate, precipitate.....lb.		.20 - .20
Zinc chloride, gran.....lb.	.12½ -	.13½ - .14
Zinc cyanide.....lb.	.49 -	.50 - .50
Zinc dust.....lb.	.09 - .11	.11 - .14
Zinc oxide, dry American.....lb.		.10 - .13
Zinc sulphate.....lb.	.03½ -	.04 - .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude.....lb.	\$1.00 -	\$1.10 -
Alpha naphthol, refined.....lb.	1.40 -	1.50 -
Alpha naphthylamine.....lb.	.35 -	.50 -
Aniline oil, drums extra.....lb.	.26 -	.30 -
Aniline salts.....lb.	.28 -	.33 -
Anthracene, 80% in drums (100 lb.).....lb.	.90 -	1.00 -
Benzaldehyde (f.f.c.).....lb.	1.00 -	1.15 -
Benidine, base.....lb.	1.00 -	1.25 -
Benidine, sulphate.....lb.	1.00 -	1.15 -
Benzoic acid, U. S. P.....lb.	1.00 -	1.10 -
Benzoate of soda, U. S. P.....lb.	.95 -	1.10 -
Benzol, pure, water-white, in drums (100 lb.).....gal.	.25 -	.29 -
Benzol, 90% in drums (100 lb.).....gal.	.24 -	.28 -
Benzyl chloride, 95-97%, refined.....lb.	.35 -	.40 -
Benzyl chloride, tech.....lb.	.25 -	.35 -
Beta naphthol benzoate.....lb.	3.75 -	4.50 -
Beta naphthol, sublimed.....lb.	.75 -	.80 -
Beta naphthol, tech.....lb.	.45 -	.55 -
Beta naphthylamine, sublimed.....lb.	2.25 -	2.35 -
Cresol, U. S. P., in drums (100 lb.).....lb.	.18 -	.25 -
Ortho-cresol, in drums (100 lb.).....lb.	.25 -	.25 -
Cresylic acid, 97-99%, straw color, in drums.....gal.	.85 -	.90 -
Cresylic acid, 95-97%, dark, in drums.....gal.	.80 -	.85 -
Cresylic acid, 50%, first quality, drums.....gal.	.60 -	
Dichlorobenzol.....lb.	.07 -	.10 -
Diethylaniline.....lb.	1.40 -	2.25 -
Dimethylaniline.....lb.	.50 -	.57 -
Dinitrobenzol.....lb.	.25 -	.37 -
Dinitrochlorobenzol.....lb.	.25 -	.30 -
Dinitronaphthalene.....lb.	.45 -	.55 -
Dinitrophenol.....lb.	.33 -	.36 -
Dinitrotoluol.....lb.	.38 -	.45 -
Dip oil, 25%, tar acids, car lots, in drums.....gal.	.65 -	
Diphenylamine.....lb.	.58 -	.75 -
H-acid.....lb.	1.75 -	2.25 -
Metaphenylenediamine.....lb.	1.20 -	1.80 -
Monochlorobenzol.....lb.	.12 -	.15 -
Monothylaniline.....lb.	1.50 -	1.75 -
Naphthalene crushed, in bbls. (250 lb.).....lb.	.06 -	.08 -
Naphthalene, flake.....lb.	.06½ -	.07½ -
Naphthalene, balls.....lb.	.08½ -	.10 -
Naphthionic acid, crude.....lb.	.75 -	1.25 -
Nitrobenzol.....lb.	.13 -	.19 -
Nitro-naphthalene.....lb.	.35 -	.45 -
Nitro-toluol.....lb.	.17 -	.20 -
Ortho-amidophenol.....lb.	4.25 -	
Ortho-dichlor-benzol.....lb.	.15 -	.20 -
Ortho-nitro-phenol.....lb.	.90 -	1.00 -
Ortho-nitro-toluol.....lb.	.27 -	.40 -
Ortho-toluidine.....lb.	.30 -	.45 -
Para-amidophenol, base.....lb.	2.60 -	3.50 -
Para-amidophenol, HCl.....lb.	2.75 -	3.25 -
Para-dichlor-benzol.....lb.	.06 -	.10 -
Paranitraniline.....lb.	1.05 -	1.25 -
Para-nitro-toluol.....lb.	1.35 -	1.50 -
Paraphenylenediamine.....lb.	2.75 -	4.00 -
Paratoluidine.....lb.	1.50 -	2.50 -
Phthalic anhydride.....lb.	1.75 -	2.15 -
Phenol, U. S. P., drums (dest.), (240 lb.).....lb.	.10 -	.13 -
Pyridin.....gal.	2.50 -	
Resorcin, technical.....lb.	3.50 -	3.75 -
Resorcin, pure.....lb.	6.50 -	7.75 -
Salicylic acid, tech., in bbls. (110 lb.).....lb.	.35 -	.40 -
Salicylic acid, U. S. P.....lb.	.40 -	.45 -
Salol.....lb.	.80 -	.90 -
Solvent naphtha, water-white, in drums, 100 gal. gal.	.22 -	.27 -
Solvent naphtha, crude, heavy, in drums, 100 gal. gal.	.19 -	.24 -
Sulphanilic acid, crude.....lb.	.25 -	.30 -

Tolidine.....	lb.	\$1.75	—	\$2.50
Toluidine, mixed.....	lb.	.45	—	.80
Toluol, in tank cars.....	gal.	.26	—	—
Toluol, in drums.....	gal.	.30	—	—
Xylidine, drums, 100 gal.....	lb.	.44	—	.50
Xylol, pure, in drums.....	gal.	.37	—	.45
Xylol, pure, in tank cars.....	gal.	.35	—	—
Xylol, commercial, in drums, 100 gal.....	gal.	.23	—	.27
Xylol, commercial, in tank cars.....	gal.	.22	—	—

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow.....	lb.	\$0.41	—	\$0.45
Beeswax, refined, yellow.....	lb.	.48	—	.49
Beeswax, white pure.....	lb.	.65	—	.68
Carnauba, No. 1.....	lb.	.88	—	.90
Carnauba, No. 2, regular.....	lb.	.65	—	.80
Carnauba, No. 3, North Country.....	lb.	.55	—	.60
Japan.....	lb.	.18	—	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.....	lb.	.06	—	—
Paraffine waxes, crude, scale 124-126 m.p.....	lb.	.06	—	.06
Paraffine waxes, refined, 118-120 m.p.....	lb.	.07	—	.08
Paraffine waxes, refined, 128-130 m.p.....	lb.	.08	—	.09
Paraffine waxes, refined, 133-135 m.p.....	lb.	.10	—	.11
Paraffine waxes, refined, 135-137 m.p.....	lb.	.12	—	.13
Stearic acid, single pressed.....	lb.	.23	—	.26
Stearic acid, double pressed.....	lb.	.27	—	.28
Stearic acid, triple pressed.....	lb.	.30	—	.33

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on earload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr. 0.930-0.940.....	gal.	\$1.05	—	—
Pine oil, pure, dest. dist.....	gal.	.85	—	—
Pine tar oil, ref., sp. gr. 1.025-1.035.....	gal.	.45	—	—
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.....	gal.	.33	—	—
Pine tar oil, double ref., sp. gr. 0.965-0.990.....	gal.	.65	—	—
Pine tar, ref., thin, sp. gr. 1.080-1.060.....	gal.	.34	—	—
Turpentine, crude, sp. gr. 0.900-0.970.....	gal.	.85	—	—
Hardwood oil, f.o.b. Mich., sp. gr. 0.960-0.990.....	gal.	.27	—	—
Pinewood creosote, ref.....	gal.	.48	—	—

Naval Stores

The following prices are f.o.b., New York, for earload lots.

Rosin B-D, bbl.....	280 lb.	\$16.80	—	\$18.25
Rosin E-I.....	280 lb.	18.50	—	20.25
Rosin K-N.....	280 lb.	21.00	—	24.00
Rosin W. G.-W. W.....	280 lb.	24.50	—	25.00
Wood rosin, bbl.....	280 lb.	17.00	—	18.00
Spirit of turpentine.....	gal.	1.75	—	—
Wood turpentine, steam dist.....	gal.	1.68	—	—
Wood turpentine, dest. dist.....	gal.	1.55	—	—
Pine tar pitch, bbl.....	200 lb.	8.25	—	8.50
Tar, kiln burned, bbl. (500 lb.).....	bbl.	12.75	—	13.50
Retort tar, bbl.....	280 lb.	13.75	—	14.50
Rosin oil, first run.....	gal.	.86	—	.91
Rosin oil, second run.....	gal.	.88	—	.93
Rosin oil, third run.....	gal.	.90	—	1.07
Rosin oil, fourth run.....	gal.	.93	—	1.10

Solvents

73-76 deg., steel bbls. (85 lb.).....	gal.	\$0.33	—	—
70-77 deg., steel bbls. (85 lb.).....	gal.	.31	—	—
68-70 deg., steel bbls. (85 lb.).....	gal.	.30	—	—
V. M. and P. naphtha, steel bbls. (85 lb.).....	gal.	.23	—	—

Crude Rubber

Para-Upriver fine.....	lb.	\$0.54	—	\$0.55
Upriver coarse.....	lb.	.31	—	—
Upriver caucho ball.....	lb.	.31	—	.32
Plantation—First latex crepe.....	lb.	.44	—	.45
Rubbed smoked sheets.....	lb.	.43	—	.43
Brown crepe, thin, clean.....	lb.	.38	—	—
Amber crepe No. 1.....	lb.	.40	—	.41

Oils**VEGETABLE**

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls.....	lb.	\$0.19	—	\$0.20
Castor oil, A.A. in bbls.....	lb.	.21	—	.22
China wood oil, in bbls.....	lb.	.22	—	.24
Cocunut oil, Ceylon grade, in bbls.....	lb.	.19	—	.20
Cocunut oil, Cochín grade, in bbls.....	lb.	.24	—	.25
Corn oil, crude, in bbls.....	lb.	.24	—	.29
Cottonseed oil, crude (f.o.b. mill).....	lb.	.28	—	.29
Cottonseed oil, summer yellow.....	lb.	.26	—	—
Cottonseed oil, winter yellow.....	lb.	.27	—	.30
Linseed oil, raw, ear lots.....	gal.	2.17	—	2.22
Linseed oil, raw, tank cars.....	gal.	2.17	—	2.19
Linseed oil, boiled, ear lots.....	gal.	2.25	—	2.30
Olive oil, commercial.....	gal.	2.30	—	2.50
Palm, Lagos.....	lb.	.17	—	.18
Palm, bright red.....	lb.	.16	—	.17
Palm, Niger.....	lb.	.16	—	.17
Peanut oil, crude, tank cars (f.o.b. mill).....	lb.	.24	—	.27
Peanut oil, refined, in bbls.....	lb.	.29	—	.30
Rapeseed oil, refined in bbls.....	gal.	1.50	—	1.60
Rapeseed oil, blown, in bbls.....	gal.	1.60	—	1.70
Soya bean oil (Manchurian), in bbls., N. Y.....	lb.	.18	—	.20
Soya bean oil, tank cars, f.o.b., Pacific coast.....	lb.	.15	—	.17

FISH

Winter pressed Menhaden.....	gal.	\$1.28	—	\$1.35
Yellow bleached Menhaden.....	gal.	1.30	—	1.37
White bleached Menhaden.....	gal.	1.32	—	1.38
Blown Menhaden.....	gal.	1.38	—	1.40

Miscellaneous Materials

All Prices f.o.b., N. Y.

Sarytes, domestic, white, floated.....	ton	\$25.00	—	\$36.00
Sarytes, off color.....	ton	20.00	—	25.00
Blanc fixe, dry.....	lb.	.03	—	.04
Blanc fixe, pulp.....	ton	35.00	—	47.50
Charcoal.....	lb.	.16	—	.18
Chalk, English, extra light.....	lb.	.05	—	.07
Chalk, English, light.....	lb.	.04	—	.06

Chalk, English, dense.....	lb.	\$.04	—	\$.05
China clay (Kaolin), imported, lump.....	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered.....	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump.....	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered.....	ton	25.00	—	40.00
Fel spar.....	ton	11.50	—	16.00
Fluorspar, acid grade, lump, f.o.b. mines.....	net ton	\$30.00	—	\$35.00
Fluorspar, acid grade, ground, f.o.b. mines.....	net ton	35.00	—	45.00
Fuller's earth, domestic, powdered.....	ton	30.00	—	40.00
Fuller's earth, imported, powdered.....	ton	—	—	—
Pumice stone, imported.....	lb.	.03	—	.06
Pumice stone, domestic.....	lb.	.02	—	—
Shellac, TN.....	lb.	1.20	—	—
Shellac, D. C.....	lb.	—	—	—
Shellac, V. R. O.....	lb.	—	—	—
Shellac, Diamond I.....	lb.	—	—	—
Shellac, orange, fine.....	lb.	—	—	—
Shellac, orange, superfine.....	lb.	1.35	—	—
Shellac, A.C. garnet.....	lb.	.95	—	—
Shellac, bleached, bone dry.....	lb.	1.40	—	—
Shellac, bleached, fresh ground.....	lb.	1.10	—	—
Soapstone.....	ton	15.00	—	25.00
Talc, domestic.....	ton	16.00	—	60.00
Talc, imported.....	ton	55.00	—	60.00

Refractories

Following prices are f.o.b. works:

Chrome brick.....	net ton	80-90 at Chester, Penn.
Chrome cement.....	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay.....	net ton	35-45 at Clearfield, Penn.
Clay brick, 2nd quality.....	net ton	30-35 at Clearfield, Penn.
Magnesite, dead burned.....	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4 1/2 x 2 1/2 in.....	net ton	80-90 at Chester, Penn.
Silica brick.....	net ton	41-45 at Mt. Union, Penn.

Ferro-alloys

All prices f.o.b. works.

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.....	net ton	\$200.00	—	\$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon.....	lb.	.30	—	.40
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon.....	lb.	.70	—	—
Ferro-manganese, 70-80% Mn.....	gross ton	100.00	—	125.00
Spiegelisen, 16-20% Mn.....	gross ton	35.00	—	50.00
Ferro-molybdenum, per lb. of Mo.....	lb.	1.85	—	2.00
Ferro-silicon, 50%.....	gross ton	85.00	—	115.00
Ferro-silicon, 75%.....	gross ton	150.00	—	175.00
Ferro-silicon, 10-15%.....	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.....	lb.	1.30	—	1.60
Ferro-uranium, 35-50% of U.....	lb.	7.00	—	—
Ferro-vanadium, 30-40% per lb. of contained V.....	lb.	5.50	—	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr ₂ O ₃	unit	\$0.60	—	—
Chrome ore, 48% and over.....	unit	.80	—	—
Coke, foundry, f.o.b. ovens.....	net ton	5.50	—	\$6.00
Coke, furnace, f.o.b. ovens.....	net ton	4.00	—	5.00
Petroleum coke, refinery, Atlantic seaboard.....	net ton	11.50	—	12.00
Fluorspar, gravel, f.o.b. mines.....	net ton	20.00	—	25.00
Manganese ore, 45% Mn and over.....	unit	.50	—	.65
Manganese ore, chemical (MnO ₂).....	gross ton	60.00	—	70.00
Molybdenite, 85% MoS ₂ , per lb. of MoS ₂	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO ₃ and over per unit of WO ₃	unit	9.00	—	12.00
Tungsten, Wolframite, 60% WO ₃ and over, per unit of WO ₃	unit	7.00	—	10.00
Uranium oxide, 96%.....	lb.	—	—	—
Vanadium pentoxide, 99%.....	lb.	6.00	—	—
Pyrites, foreign, lump.....	unit	.15	—	—
Pyrites, foreign, fine.....	unit	.15	—	—
Pyrites, domestic, fine.....	unit	.14	—	.17
Ilmenite, 52% TiO ₂ , f.o.b. N. Y.....	net ton	38.15	—	—
Rutile, 95% TiO ₂ , f.o.b. N. Y.....	net ton	200.00	—	—
Carnotite, minimum 7% U ₃ O ₈ , per lb. of U ₃ O ₈	lb.	2.75	—	3.00
Zircon, washed, iron free, f.o.b. N. Y.....	net ton	125.00	—	—
Monazite, per unit of ThO ₂ , f.o.b. N. Y.....	unit	42.00	—	—

Plant Materials and Supplies

In earload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags.....	bbl.	\$2.30	—	—
Lump lime, common, including container.....	300 bbl.	2.65	—	—
Common brick, at dock.....	M.	15.00	—	—
Yellow pine, 3x4 to 8x8, 20-24 ft. long.....	M.	40.00	—	—
Yellow pine, 3x4 to 8x8, 20-24 ft. long at Chicago.....	M.	39.50	—	—
Yellow pine, 3x4 to 8x8, 20-24 ft. long at St. Louis.....	M.	37.00	—	—
Roofing, tar felt (14 lb. per 100 sq.ft.).....	ton	60.00	—	—
Roofing, tar pitch (in 400-lb. bbl.).....	ton	21.00	—	—
Roofing, asphalt pitch.....	ton	34.00	—	—
Roofing, asphalt felt.....	ton	63.00	—	—
Roofing, slate-surfaced, per roll of 108 sq.ft.....	—	2.00	—	—
Roofing, slate-finished shingles, 100 sq.ft.....	—	5.00	—	—
Linseed oil, raw in barrels.....	gal.	2.25	—	—
Linseed oil, 5 gal. cans.....	gal.	2.40	—	—
Red lead, dry, 100 lb. keg.....	lb.	.13	—	—
Red lead, in oil, 100 lb. keg.....	lb.	.14	—	—
Red lead, dry, 5 lb. cans.....	lb.	.15	—	—
Red lead, in oil, 5 lb. cans.....	lb.	.16	—	—
White lead, dry and in oil, 100 lb. kegs.....	lb.	.13	—	—
White lead, dry and in oil, 25 and 50 lb. kegs.....	lb.	.13	—	—
White lead, dry and in oil, 5 lb. cans.....	lb.	.15	—	—

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.....	100 lb.	\$2.45	—	—
Angles, 3 to 6-in., 1-in. thick.....	100 lb.	2.45	—	—
Tees, 3-in. and larger.....	100 lb.	2.45	—	—
Plates.....	100 lb.	2.66	—	—
Rivets, structural, 1-in. and larger.....	100 lb.	4.20	—	—
Rivets, conehead for boilers, 1-in. and larger.....	100 lb.	4.30	—	—
Sheets, No. 28 black.....	100 lb.	4.35	—	—
Sheets, No. 10 blue annealed.....	100 lb.	3.55	—	—
Sheets, No. 28 galvanized.....	100 lb.	5.70	—	—

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

WARREN—The Phelps Dodge Corporation, Douglas, plans to build a concentration plant at copper mines. H. K. Burch, c/o owner, engineer.

California

HUNTINGTON PARK—The Southern California Iron & Steel Co., 417 Mateo St., Los Angeles, plans to build an iron and steel fabricating plant consisting of about 8 buildings to include an open-hearth mill, nut, rivet, forge and machine shop and galvanizing building, etc. Estimated cost, \$1,750,000.

PITTSBURGH—The Columbia Steel Co., 503 Market St., San Francisco, will erect a steel and corrugated iron rolling plant. Estimated cost, \$250,000. Work will be done by day labor.

TORRANCE—The Torrance Window Glass Co. plans to rebuild the glass factory, consisting of several frame, galvanized iron and brick buildings which were recently destroyed by fire. Estimated cost, \$25,000.

Connecticut

BRIDGEPORT—The Bridgeport Brass Co., Grand St., soon lets contract for the construction of a 1-story, 150 x 226-ft. addition to its casting shop. Estimated cost, \$150,000. The H. M. Lane Co., 701 Owen Bldg., Detroit, Mich., engineer.

GLENBROOK—C. A. Phillips Chemical Co. has awarded the contract for the construction of a 2-story factory, to Thompson & Brown, 283 Madison Ave., New York City. Estimated cost, \$55,000.

MYSTIC—The Packer Tar Soap Co., Lincoln Ave., plans to build additions to plant, to include a 1-story storage building, 1-story factory and a 25 x 30-ft. power house. Estimated cost \$40,000. Bilderbeck & Langdon, Inc., Barrows Bldg., New London, engineer.

WINDSOR LOCKS—C. H. Dexter & Son, Inc., will soon award the contract for the construction of a 5-story, 55 x 100-ft. paper mill addition. Estimated cost, \$100,000. Greenwood & Noerr, 847 Main St., Hartford, engineer.

Delaware

NEWARK—The Continental Fibre Co. has awarded the contract for the construction of a 2-story, 60 x 240-ft. factory to the Austin Co., Bulletin Bldg., Philadelphia. Estimated cost, \$56,000.

YORK LYN—The National Fibre Insulation Co. has awarded the contract for the construction of a 2-story, 60 x 140-ft. factory, to the Austin Co., Bulletin Bldg., Philadelphia. Estimated cost, \$40,000.

Idaho

CEUR D'ALENE—The Home Builder Mine & Milling Co. plans to build the first unit of nitrate plant on the shore of the Ceur d'Alene Lake. Estimated cost, \$50,000. W. C. Brower, Spokane, Wash., metallurgical chemist.

LEONA—The Idaho Lead & Copper Co., 507 Eagle Block, Spokane, Wash., plans to build 1600 ft. of underground workings and will install a 50-ton mill and compressor. Estimated cost, \$40,000. E. J. Merrin, president.

Illinois

SALEM—The city has awarded the contract for the construction of a reinforced concrete, brick and steel water filtration plant here, to W. C. Johnson Construction Co., South High St., Belleville. Total estimated cost, \$12,000.

Iowa

CLARINDA—The city has awarded the contract for the installation of 2,500,000

gal. rapid sand filters, to the Pittsburg Filter Manufacturing Co., c/o E. W. Bacharach, Western manager, 429 Rialto Bldg., Kansas City, Mo. Estimated cost, \$11,000.

CORNING—The city will soon award the contract for sewer improvement and a disposal plant. Estimated cost, \$40,000. Archer & Stevens, 609 New England Bldg., Kansas City, Mo., engineer.

DEXTER—The city plans to build a sewer system and sewage disposal plant involving 1030 cu.yd. filter sand and 82 cu.yd. of filter gravel. H. H. Hough, city clerk.

INWOOD—The city will soon award the contract for the construction of a complete sewer system and sewage disposal plant. C. H. Currie, Webster City, engineer.

POCAHONTAS—The city will soon award the contract for the construction of a complete sewer system and sewage disposal plant. C. H. Currie, Webster City, engineer. Noted June 1.

Kansas

BLUE MOUND—The Vinegar Hill Zinc Co., Baxter Springs, plans to install a flotation machine, and is changing entire mill from gas to electric power at its Barr mine here. Is in market for motors and transformers. J. G. Trewartha, superintendent.

TREECE—Waugh & Jones Co., Baxter Springs, has recently taken over the old De Armand mill and plans to enlarge table room and change from steam to gas power. Is in the market for 5 tables, 1 set rolls and 3 gas engines. W. Waugh, manager.

WICHITA—The Sinclair Refining Co. plans to construct an oil distributing plant, to consist of several buildings. Estimated cost, \$150,000. C. W. Birdsall, c/o owner, architect.

Maryland

BALTIMORE—Sherwood Bros., Bank and 8th Sts., plans to construct a 2-story, 75 x 200-ft. oil refinery and warehouse. Estimated cost, \$100,000.

HAGERSTOWN—The Green Mining Co., 7 East Washington St., plans development green stone quarry near here and will install 100-ton daily capacity mill. A. Ludwig, manager.

Massachusetts

EAST SPRINGFIELD—The Atlantic Refining Co., 503 Turks Head Bldg., Providence, R. I., has awarded the contract for the construction of a 2-story oil plant on Page Blvd. and Robbins Rd., to Metzger & Fisher Co., Otis Bldg., Philadelphia. Estimated cost, \$50,000.

Michigan

DETROIT—The Detroit Soluble Oil Co., Beard St. and Michigan Central Railroad, has purchased site on Dix Ave. and plans to erect a factory for cutting oil, there. Architect not selected.

HIGHLAND PARK (Detroit P. O.)—The Maxwell Motor Co., Oakland Ave., will receive bids until Sept. 7 for the construction of a 1-story, 315 x 557-ft. pressed steel plant at Oakland and Massachusetts Aves. Stamping equipment, consisting of presses, rolls and furnishing tanks, will be installed. Smith, Hinchman & Grylls, Washington Arcade, Detroit, architects.

ROYAL OAK (Vinsetta Park Subdivision)—M. L. Brown & Son, engineer, 821 Chamber of Commerce Bldg., Detroit, will receive bids for furnishing labor and material for complete sewer system and disposal works, to include an 8 x 10-ft. vitrified crock, Imhoff tank, ejector station and sprinkling filter system, for the Vinsetta Land Co. Estimated cost, \$25,000.

Minnesota

ST. PAUL—The St. Paul Welding Co., 173 West 3rd St., is having plans prepared for the construction of a 2-story, 36 x 75-ft. welding shop. Estimated cost, \$115,000. M. A. Wright, Pittsburgh Bldg., St. Paul, architect.

Missouri

HOLDEN—The city has awarded the contract for the construction of a sanitary sewer system and disposal plant, to J. O'Neil Leavenworth, Kan. Estimated cost, \$57,000.

LIBERTY—The William Jewell College plans to construct a new college to include a science department. Laboratory equipment will be installed in same. Estimated cost, \$200,000.

MARYVILLE—The city is receiving bids for the construction of 2 reservoirs, reinforced coagulating plant, etc. Estimated cost, \$75,000. W. E. Harper, 2408 East 30th St., Kansas City, engineer.

MARYSVILLE—A. D. Hewett, city clerk, will soon receive bids for the construction of a water filtration plant. Estimated cost, \$50,000.

MILAN—The city has awarded the contract for the construction of a sanitary sewer, including disposal plant, to J. O'Neil Leavenworth, Kan. Estimated cost, \$29,000. Noted Aug. 15.

ST. LOUIS—The Mississippi Valley Iron Co., 6500 South Broadway, has awarded the contract for the construction of a 1-story, 29 x 82-ft. engine house, and a 36 x 93-ft. gas producing factory, to the Pruin-Connon Construction Co., Merchants Laclede Bldg. Estimated cost, \$32,000.

ST. LOUIS—The Parker Russell Mining & Manufacturing Co., Laclede Gas Bldg., has awarded the contract for the construction of a 2-story, 98 x 129-ft. silica factory, to J. C. Settle & Co., Pontiac Bldg. Estimated cost, \$20,000. Noted May 15.

Montana

SCOBEY—The city council has awarded the contract for the construction of a sewer system, to include manholes, settling tank and sludge beds, to G. W. Kemper, Minot, N. Dak. Estimated cost, \$49,485. Noted Aug. 15.

LIBBY—The Lukens Hazel Mining Co. plans to build a 200-ton concentration plant and to increase power plant and develop 600-hp. system by installing pipe line from Granite Creek to Lukens Hazel Mine. Also plans to install compressor, jigs, tables and flotation machines. Estimated cost, \$240,000. Oscar Nordquist, superintendent.

New Jersey

NEWARK—The American Platinum Works, New Jersey Railroad Ave., has awarded the contract for the construction of a 3-story, 50 x 130-ft. reinforced concrete building, to Fred Kilgus, Inc., 13 Sixth St. Estimated cost, \$100,000.

ORANGE—The Board of Freeholders of Essex County, Newark, received low bid for the construction of a sewer disposal plant for sanatorium in Orange Mts., from Averill Mahlon Construction Co., 31 Clinton St., \$90,000.

New York

ALBANY—Charles F. Rattigan, superintendent of prisons, will receive bids Sept. 4 for the construction of a concrete dam, cast iron pipe line and mechanical gravity filter plant at Wingdale Prison, Wingdale, N. Y.

BROOKLYN—The E. A. Laboratory, Inc., 80 Broadway, has awarded the contract for the construction of a 2-story, 100 x 100-ft. factory, at Spencer St. and Myrtle Ave., to Barney Ahlers Construction Co., 110 West 40th St., New York City. Estimated cost, \$95,000. B. Driesler, 153 Remsen St., architect.

MIDDLETOWN—The Middletown State Homeopathic Hospital Commission received bids Aug. 20 for furnishing all labor and material complete for the construction work of mortuary and laboratory, from Giles Construction Co., \$21,062, and A. E. Stephens Co., Springfield, Mass., \$28,800.

North Carolina

RUTHERFORDTON—The city has awarded the contract for the construction of a filtration plant in connection with the proposed waterworks system, to the Norwood Engineering Co., Rutherfordton.

STATESVILLE—The city will receive bids Sept. 16 for the construction of a concrete filter plant, 1,000,000-gal. capacity. Former bids were rejected. R. L. Greenlee, Raleigh, engineer.

Ohio

CLEVELAND—The Cuyahoga Galvanizing Co., 1280 East 59th St., has awarded the contract for the construction of a 1-

story, 60 x 100-ft. factory on 3352 Payne Ave., to G. R. Atkin, 9212 Hough Ave. Estimated cost, \$10,000. Noted Aug. 15.

CLEVELAND—The Enamel Products Co., 341 Eddy Rd., plans to build a 2-story, 180 x 40-ft. addition to factory. Estimated cost, \$10,000.

CLEVELAND—The Standard Brass & Foundry Co., 990 East 67th St., is receiving bids for the construction of a 2-story, 38 x 59-ft. office building and shop. Estimated cost, \$10,000.

CLEVELAND—The Ohio Carbon Co., 3620 Lorain Ave., has awarded the contract for the construction of a 1-story, 51 x 100-ft. factory on 8219 Almira Ave., to Uhl & Jasper Co., 1900 Euclid Ave. Estimated cost, \$15,000.

COLUMBUS—The Tinker Roller Bearing Co., Dueber Ave., Canton, has awarded the contract for the construction of a 1-story, 282 x 482-ft. factory, at 5th and Cleveland Aves., to D. W. McGrath, New First National Bldg. Estimated cost, \$550,000.

DOVER—The Tuscora Rubber Co. is receiving bids for the construction of a 3-story, 200 x 300-ft. rubber factory here. Estimated cost, \$300,000. W. C. Owen Co., 1900 Euclid Ave., architect.

Oklahoma

COLLINSVILLE—The city plans election Sept. 3 to vote on \$40,000 bond issue for the construction of a water purification plant—filters, settling basins, etc. Johnson & Benham, Firestone Bldg., Kansas City, Mo., engineer.

ENID—The city voted \$500,000 bonds for improving water system, extending sewers and building disposal plant. Black & Veach, Interstate Bldg., Kansas City, Mo., engineer. Noted July 1.

IDABEL—The city has awarded the contract for the construction of sanitary sewers and sewage disposal plant, to include 2 Imhoff tanks with contact beds and filters, to the Empire Construction Co., Kansas City, Mo. Estimated cost, \$119,800. Noted Aug. 1.

SUNNYSIDE (McLeod P. O.)—The West Virginia Mining Co., Baxter Springs, Kan., plans to construct a mill and is in the market for entire equipment for same. J. Hatton, superintendent.

Oregon

BEND—The Oregon Nitrate Co. plans to develop Stinking Lake and Sheep Mountain nitrate deposits by installing crystallization evaporation system and crushing plant. Estimated cost, \$25,000. J. H. Morgan, Bend, president.

SUMMER LAKE—J. Moore plans to erect a 1-story soda ash and potash plant here, capacity 10,000 tons. Estimated cost, \$190,000.

Pennsylvania

MORRISVILLE—The city plans to build a sewage system and disposal plant. Estimated cost, \$265,000. T. E. Howe, East Rutherford, N. J., engineer.

PHILADELPHIA—The General Manufacturing Co., Delaware and Bigler Aves., has awarded the contract for the construction of a 3-story, 100 x 300-ft. factory and storage building, to H. P. Friend, Inc., Arcade Bldg., Boyer St., Norristown.

Texas

SAN ANTONIO—The Bear Rubber Mills, Ltd., plans to construct a 1-story, 300 x 360-ft. factory on Frio City Rd. Estimated cost, \$200,000. Gulick, Hoff & Ries, 309 Frost Bldg., engineers.

Virginia

BERRYVILLE—The town is having plans prepared for the construction of a new water filtration plant by Gannett, Seelye & Fleming, Harrisburg, Pa., engineers.

ORANGE—The town voted \$70,000 bonds for improving waterworks system, including filter plant, pumping equipment and force main. A. J. Harlow, mayor.

SUFFOLK—The Eastern Oil Co. plans to build plant for the manufacture of cottonseed and peanut oils, daily capacity 75,000 tons. Estimated cost, \$125,000.

Wisconsin

BEAVER DAM—The Malleable Iron Range Co. has awarded the contract for the construction of a 2-story foundry addition, including an annealing department, to the Hutter Construction Co., Fond du Lac. About \$30,000.

CUBA CITY—The Connecting Link Manufacturing Co. plans to erect two jig mills and install machinery assembled last fall in the zinc and lead mine 4½ miles northeast of here. Estimated cost, \$24,000. Theodore Waech, superintendent.

JANESVILLE—The Samson Tractor Co., Division of the General Motors Corporation, 88 East Congress St., Detroit, Mich., is building a plant to include a gray iron foundry, core room, sand storage building and pattern shop, to cover an area of 330 x 530 ft. Estimated cost, \$1,000,000. Frank D. Chase, Inc., 645 North Michigan Ave., Chicago.

KOHLER—The Kohler Co., c/o W. J. Kohler, will soon award the contract for the construction of a 4-story, 180 x 260-ft. enamel ware factory, on Elm St. Estimated cost, \$40,000. Brust & Phillip, Free Press Bldg., Milwaukee, architect.

LINDEN—Piquette & Altenberg, Platteville, plan to erect a mill and install machinery in the zinc mine here. Estimated cost, \$10,000. J. Piquette, superintendent.

PESHTIGO—The Peshtigo Pulp & Paper Co., address J. A. Kittle, president, has awarded the contract for the construction of a 1-story, 70 x 242-ft. paper mill on Main St., to the Jorgenson Construction Co., Main St., Denmark. Estimated cost, \$60,000. Noted Aug. 1.

SCHULSBURY—The Local Co. plans to erect a mill and install a gasoline or oil engine and jigs in the zinc and lead mine three miles northwest of here. Estimated cost, \$7,000-\$8,000. R. F. Fox, superintendent.

TAYCHEEDAH—The State Engineer's office, Capitol, Madison, will receive bids until Sept. 5 for the construction of 10-in. sewer, 1 sewage disposal plant, consisting of tanks and filters, 262 linear feet of 5 x 8 ft. 6 in. tunnel for the Industrial Home for Women here.

Ontario

BOSTON CREEK—The Patricia Mining Co. plans to erect a mining plant and refinery and is in the market for all equipment.

LONDON—C. S. Hyman & Co., Richmond, Ohio, has awarded the contract for the construction of a 3-story, 80 x 100-ft. addition to tannery, to P. H. Secord & Son, Nelson St., Brantford. Estimated cost, \$300,000. Noted Aug. 15.

Manufacturers' Catalogs

THE WELLMAN-SEEVER-MORGAN Co., Cleveland, Ohio, has issued Bull. No. 22, dated June, 1919, which contains charts giving the relations in any shaft between power, shaft diameter, torsional stress and speed.

TATE-JONES & Co., Pittsburgh, Pa., has published several booklets: Bull. No. 158 deals with fuel oil burners for furnaces; Bull. No. 157 treats of fuel oil burners for boilers; Circular No. 129 describes fuel oil burning equipment for open-hearth furnaces. "Fuel Oil and Its Use" is the title of another new booklet gotten out by this company.

THE SPRAY ENGINEERING Co., Boston, Mass., is distributing Bull. 257 on "Spray Air Washing and Cooling Equipment," which is especially applicable for steam turbine generators.

HOLZ & Co., Inc., New York City, announces Bull. No. 4 on "A Machine for Determining the Resistance of Metals and Alloys to Abrasion (Wear)," which describes the Universal Type for tests on rolling or sliding surfaces, dry or lubricated, under variable speeds and pressures.

Coming Meetings and Events

THE AMERICAN CERAMIC SOCIETY will hold a meeting in Chicago, Sept. 24.

THE AMERICAN CHEMICAL SOCIETY will hold its Fall meeting in Philadelphia, Pa., Sept. 2 to 6 inclusive.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its Fall meeting in Chicago, Sept. 23 to 25 inclusive.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its 1919 convention in Philadelphia, Sept. 29 to Oct. 4.

THE AMERICAN GAS ASSOCIATION will hold its annual convention and exhibition of gas appliances and apparatus at the Hotel Pennsylvania, New York, Oct. 13 to 18.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its Fall meeting in Chicago, Ill., Sept. 22 to 27.

THE AMERICAN PEAT SOCIETY will hold its thirteenth annual meeting at Minneapolis, Minn., Sept. 22 to 24 inclusive.

THE AMERICAN STEEL TREATERS' SOCIETY will hold its first annual convention in Chicago, Ill., Sept. 22 to 27.

THE FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in Chicago, Ill., Sept. 22 to 27 inclusive.

THE ILLINOIS MANUFACTURERS' ASSOCIATION will hold a National Conference on "Our Country First" in Chicago, Sept. 8 and 9.

THE INSTITUTE OF METALS DIVISION of the A. I. M. E. will hold its next meeting in Philadelphia, Pa., Sept. 29 to Oct. 4.

THE NATIONAL SAFETY COUNCIL will hold its Eighth Annual Safety Congress in Cleveland, Oct. 1 to 4.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its Fall meeting in Chicago from Sept. 24 to 27.

Stocks and Bonds

Closing Bid and Asked Quotations Aug. 28, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am. Ag. Ch....	97	99	Mat. Al. Wk....	31	34
do. pf.	97	99	Ten. C. & C. 13½	13½	13½
Barrett Co....	118	119	Un. Dyewood ..	...	...
do. pf.	113	113	do. pf. ....	...	...
Gen. Chem....	179	179	Va.-Car. Chm....	80	81
do. pf.	103½	108	do. pf.	113½	114½
Int. Ag. Ch....	25	27			
do. pf.	82	84			

Bonds

Am. Ag. Ch., 1st ev. 5s, '28.....	94	100
Am. Ag. Ch., ev. db. 5s, '24.....	101½	107
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32.....	83	83½
Va.-Car. Ch., 1 mtg. 5s, '23.....	95½	95½
Va.-Car. Ch., ev. db. 6s, '24.....	102	103

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co....	88	90	P-A Pet & Tr 109½	109½	109½
Cal. Pet.	44	44½	do. pf. ....	...	...
do. pf.	80	82	Pierce Oil....	20½	20½
Col. G. & E....	61	61½	Royal Dutch. 89½	89½	89½
Mex. Pet.	176	176½	Sinclair O&R. 57	57½	57½
do. pf.	107	112	Texas Co....	249	250
Ohio Cit. Gas. 51½	52	52	Tex. Pac. Ld....	365	465
do. pf.	50	50½	Tr.	238	245
Ohio Fuel S....	50	50½	Tidewater Oil	238	245
Okl. P. & R. 10	10½	10½			

Bonds

Columbia Gas & Electric, 1 5s, '27.....	89	89½
Col. G. & E., std. 1 5s, '27.....	87	89½
Pan-Am. Pet. & Tr. 1 6s, '19-27.....	180	180
Pierce Oil, ev. db. 6s, '24.....	104½	104½
Pierce Oil, cv. 5% Notes, '20.....	105½	120
Sin. O. & R. 1 ln. 7s, '20, with stk. war....	...	...
Sin. O. & R. 1 ln. 7s, '20 without stk war....	...	...
Texas Co., db. 6s, '31.....	102½	102½
Union Oil of Cal. 1 5s, '31.....	94	95
United Fuel Gas 1 mtg. 6s, ser. A, '36.....	96	98

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F....	39½	40½	Pitts. Ste. pf. 88½	95	95
Beth. Steel....	80	84	Rep. Iron & S.	87	87
do. class B....	84	84½	Steel.....	86½	87
do. pf.	111½	114	do. pf.	104½	105½
do. pf. 7% 100	107	107	Sloss Sheff. I.	62½	63½
Central Fdry. 26	30	30	& S.....	62½	63½
do. pf.	55	63	do. pf.	90	95
Col. F. & I....	43	44	Superior Steel 39½	42	42
do. pf.	153	153½	do. I pf....	102	...
Cruc. Steel....	153	153½	Trans. & W....	56	57½
do. pf.	42	42½	Steel.....	51	52½
Great No. Ore 42	42½	42½	Un. Alloy St. 51	52½	52½
Gulf Sta. Steel 56	59	59	U.S.C.I.P. & F. 31	32	32
do. I pf....	94	98	do. pf.	67	70
Lack. Steel....	77	77½	U. S. Steel....	102	102½
Mid. St. & Ord. 50½	50½	50½	do. pf.	114½	115
Nova Scotia	72	72½	Va. Coal, I & C 60	61	61
Steel.....	72	72½			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26.....	96½	97
Beth. Steel, 1 ln. ref. 5s, Ser. A, '42.....	88½	89½
Beth. Steel, P. M. & I. S. F. 5s, '36.....	85½	86½
Buff & Susq. Iron, 1 S. F. 5s, '32.....	90	91
Buff & Susq. Iron, deb. 5s, '27.....	90	90
Cent. Found., 1 mtg. S. F. 6s, '21.....	86	86½
Col. F. & I., gn. S. F. 5s, '43.....	90½	91
Ill. Steel, db. 4½s, '40.....	84½	85½
Ind. Steel, 1 mtg. gtd. 5s, '52.....	95½	95½
Lack. Steel, 1 5s, '23.....	96½	97
Lack. Ste., 1 con. mtg. ev. 5s, Ser. A, '50, 92	92	92
Mid. St. & Ord., elt. cv. S. F., 5s, '36.....	87	88
Nat. Tube, 1 mtg. gtd. 5s, '52.....	94	95
Rep. I. & S., S. F. mtg., 5s, '40.....	93½	93½
Tenn. C. & I. R.R. 'gn. 5s, '51.....	87	89½
U. S. Steel, S. F. 5s, '63.....	100	100½
Va. C., I. & C., 1 5s, '49.....	84	85½